PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

The Speed-Up in Progress

EVERY GREAT WAR has been productive of great revolutions in all the spheres of human activities and relationships. Many of the world's greatest advances in the field of medicine and surgery had their inception on bloody battlefields. In times of strife, the ingenuity of man, urged to ever greater effort by the pressure of events, has contrived the most deadly weapons of both chemical and mechanical warfare. And following each great war there have come sweeping revolutions in forms of government and social and economic relationships.

This war will be no exception. Already one can see all about us activities that presage great changes in future industrial activities. Automobile companies are now beginning to build airplane engines, calling for much finer engineering design and manufacturing methods. Railroad car shops are building tanks, forge shops are making shells, and automobile hardware manufacturers are making sensitive shell-fuse timers. Many other examples could be cited.

As stated by the vice-president in charge of engineering of an automobile manufacturing company, "By the time this war is over our experiences in making airplane engines will have taught us how to make automobile engines so vastly better that we will think of our present engines as having been crude machines." The same kind of a statement could be made by industrial executives in many other fields.

The pressing problem is to attain a tremendous output of these highly accurate machines and instruments of war with a minimum of machining time and labor. This condition coupled with the fact that many companies are tackling manufacturing requirements that are new to them, is being productive of startling new developments in manufacturing methods. Companies are swapping information and experiences. Shop men face to face with the necessity of developing manufacturing processes entirely new to them, unhampered by prejudice or tradition, are doing things that many experienced men "know better than to try," while men with long experience in a specific manufacturing process are actively seeking short cuts.

One company has found how to eliminate the grinding operation on the teeth of hardened precision gears; in another plant brazed assemblies of stampings have supplanted machined forgings. Resistance welded stampings have greatly simplified the dies and speeded production, and local hardening by induction heating is being used to speed the production of screw machine parts. There are many other examples of a similar nature.

To keep up with all the new manufacturing methods now coming to the forefront will be a difficult task for the design engineers. But do it he must if he is to design his parts and products suitable for the most economical manufacturing methods that might be employed. And today, economy of manufacturing is not being measured by dollars and cents costs alone, but in many instances by the time and labor required to produce. That applies equally to both armament orders and products for peace time use. We are now at the beginning of a great revolution, a sweeping revolution in engineering design impelled by new production techniques.

CONTROL CIRCUITS

Factors That Influence the Choice of Voltage

OF ALL the factors that enter into the selection of the voltage to be used for an electric control circuit, the most debatable one is the consideration of safety. Questions relating to the electrical problems involved, space limitations and cost can be at least partially answered by the results of computations. And for the unusual cases where the electrical systems must be able to operate on storage batteries, as in railroad cars, airplanes and other vehicles, the storage battery voltage definitely fixes the control circuit voltage. But the answer to the question as to what is a safe voltage is almost entirely a matter of judgment and opinion.

Numerous instances have occurred wherein 110 volts have caused death or serious accidents. Fatalities have occurred at even lesser voltages. A light shock may throw an operator into the machine or work, or cause him to fall, with consequent serious injury. Hence it is futile to argue whether or not a certain voltage is dangerous.

Most electrical engineers contend that regardless of the voltage, be it 6 volts or 440 volts, complete safety can be obtained by proper and reasonable cautions in the design of the control circuit. Hazards associated with high voltage can be guarded against with complete assurance if the following design specifications are observed:

Fig. 1—Pendant pushbutton station used on Ingersoll milling machines, shows possibilities in space saving when low voltage control circuits are used

1. Circuits above 24 volts should be in conduits or raceways.

2. Pushbuttons and other contacts should be arranged so there will be no two adjacent points of opposite polarity.

3. All boxes, inclosures, pushbuttons, should be securely grounded through conduit systems. If flexible non-metallic covered cables are used, ground by an extra grounding conductor.

4. Use proper wire insulation for conditions such as oil, water or acids. Some synthetic insulated wires are not only resistant to such conditions but also have a smaller overall diameter for more compact installation. Some designers use lead-sheathed cable.

5. Disconnecting plugs should have extra grounding conductor and terminals.

6. Conduits and boxes should be solidly clamped. For over 150 volts to ground use double locknuts on conduit terminals.

7. Use grommets or bushings when

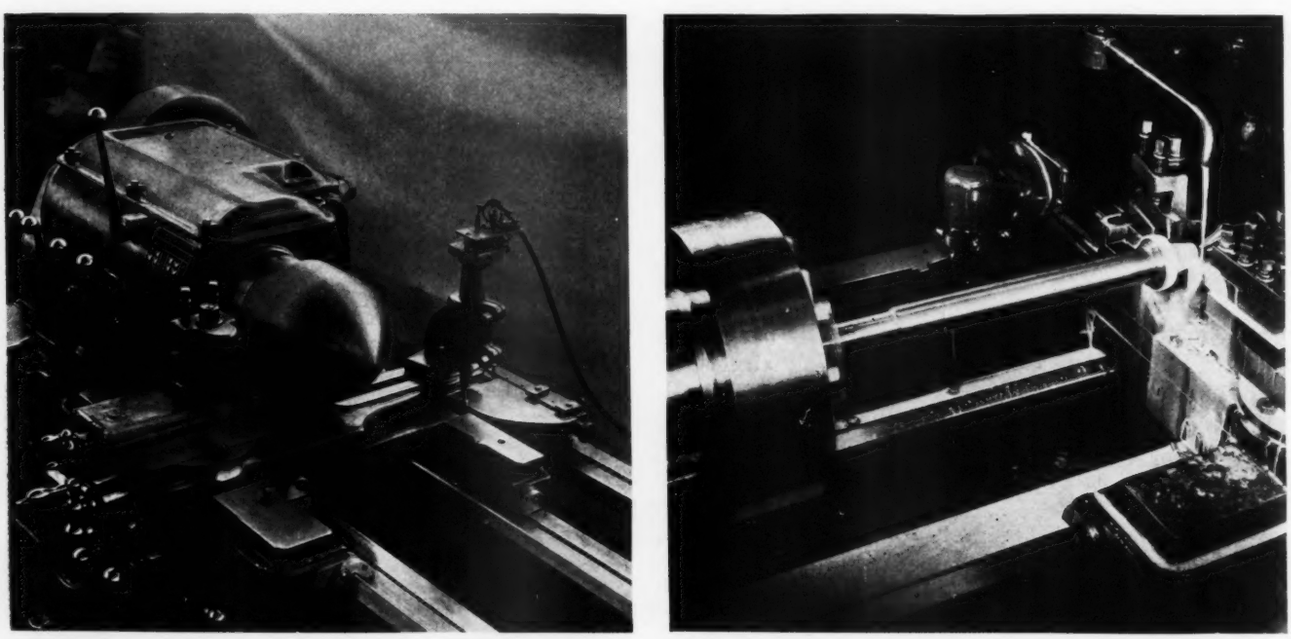


Fig. 2—Where magnetic contactors are used to follow contours low voltages are used to prevent or reduce arcing between tracer and template with consequent improvement in accuracy. In the Monarch lathe sizing device 12 volts are used on tracer circuits

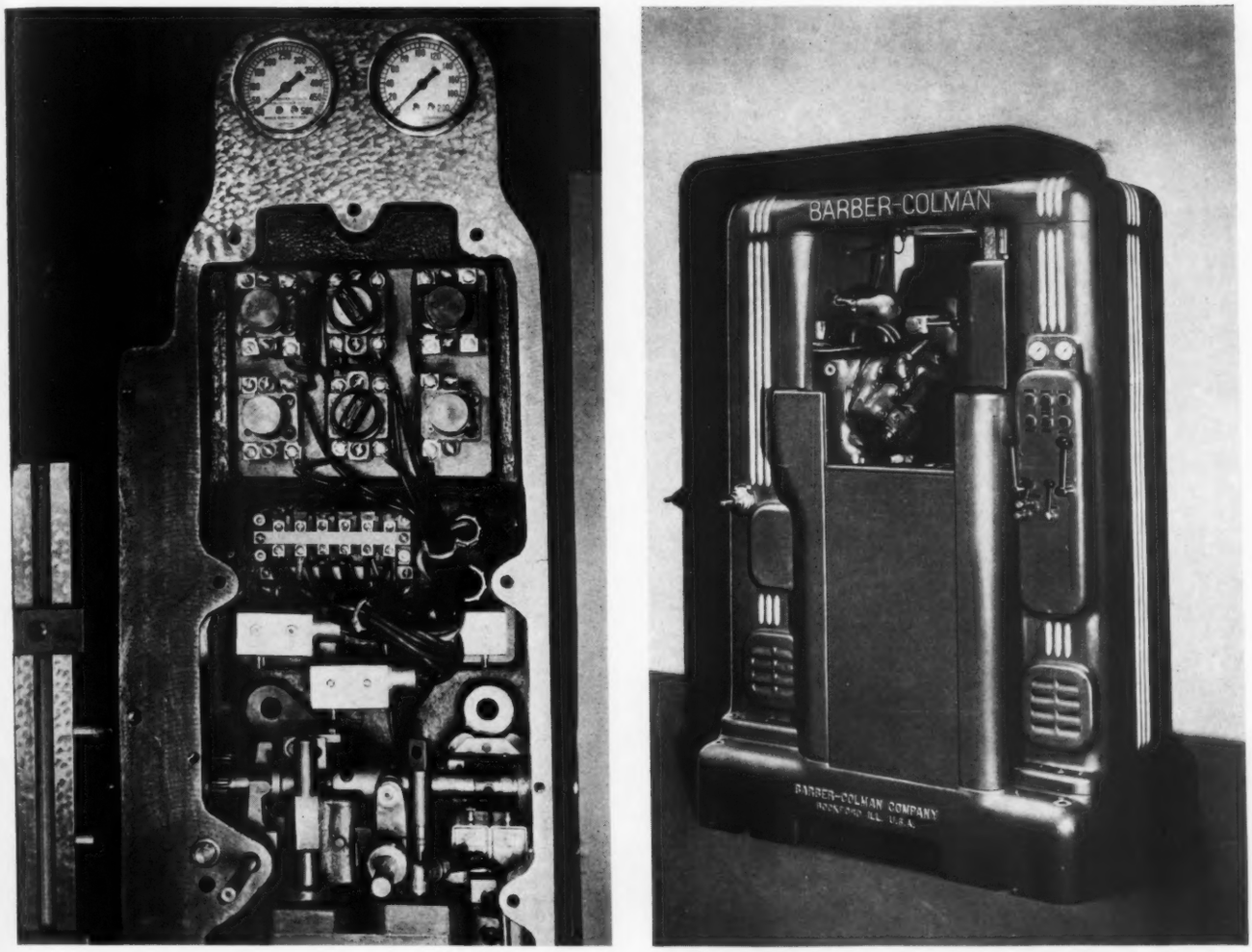


Fig. 3—Installation of electrical equipment in confined space is often required. Left, view in back of control panel of Barber-Colman vertical hobbing machine, right. Note five Micro switches and pushbutton controls for comprehensive sequence of operations

passing wire or cables through the machine frames.

8. Use threaded fittings or the threadless equivalent for all systems subject to vibration. Ordinary locknut and bushing conduit terminals are not always satisfactory on machine wiring.

9. Good practice dictates that no conduits should be brought into top of inclosures mounted directly on machine since oil might run along conduit and get into control box.

10. Plans for installation of the electrical equipment should be made on the drawing board and wherever possible "crowding" should be avoided particularly at the higher voltages. N.E.M.A. requirements for minimum installation clearances should be observed. If the space restrictions are such that these minimum clearances cannot be obtained, a lower voltage should be used.

It is simplest to operate the control circuits at full line voltage. No transformer is required, no relays are needed to operate the contactors. However, if the power circuit is 220 volts or 440 volts, the control circuit might be operated off the 110 volt lighting circuit. According to a survey conducted among 50 machine tool engineers, most of them favor 110 volt control circuits, many favor using line voltage up to 220 volts, and low voltage control circuits such as 12, 32, or 64, are used only to meet special conditions. However, one automobile plant recently standardized on 32 volts for all pushbutton circuits and 110 volts for limit switches.

There are a number of advantages as well as disadvantages in the use of full line voltage control circuits besides the elimination of the transformer, mercury arc or copper oxide rectifier or other type of voltage transformer. For a given amount of power required to operate the contactors and relays, the current required will be inversely proportional to the voltage. Smaller pushbuttons and limit switches can therefore be used when the control circuit voltage is higher. At low voltages the higher amperage will require greater contact areas to avoid overheating. This situation can be avoided by using relays in the low voltage control circuit, these relays controlling standard voltage solenoid coils or magnets. This requires added electrical devices and circuits but where interlocking control circuits are used, the relays would be required anyhow.

In electrically driven machines that have a number of motors with perhaps also motor operated rheostats and clamps, solenoid operated valves for air, hydraulic oil or coolant, the size of the control panel becomes an important consideration. The problem becomes even more important when the control panel must be portable as on a large boring mill or planer wherein the control station is suspended from a swinging arm so that the operator can move it with him to the different working positions around the machine. Such machines often require as many as 30 buttons in the control panel.

Since the minimum allowable electrical clearance determines the minimum spacing of the pushbuttons, a low

voltage control circuit in conjunction with operating relays permits a more compact design and thereby a smaller control panel. Pushbuttons to operate on 12 or 24 volts can be located on 1⅛ in. centers. Fig. 5 indicates the possibility in space saving with lower control voltages.

In many machines, saving space in the design of the control panel is of little importance.

Usually, a portable control panel is not required and there are only a few pushbuttons. The size of the control panel is often dictated not by electrical requirements but by the demand of convenience of operation, such as mushroom type pushbuttons, guards to prevent accidental starting, and similar features.

Voltage drop across the pushbutton contacts is a major consideration in the selection of the control circuit voltage. High control circuit amperages in low voltage circuits have pyramiding effects. Higher currents are conducive to the more rapid oxidation of the contact points, thereby increasing their resistance. The higher resistance in conjunction with the higher current, increases the RI drop or voltage drop across the contacts. This may become serious, especially if there are a number of contacts in series in the circuit. For example, a three-volt drop across contacts in a 220-volt control circuit means a drop of only about 1½ per cent, which would be negligible. But a three-volt drop in a 12-volt circuit would be a drop of 25 per cent, which would seriously affect solenoid or magnetic contactor operations. Obviously a low voltage control circuit is more sensitive to the effects of decreased contact pressures and contact areas and the pitting and oxydizing of the contacts. Therefore, special care must be taken to provide dust-proof and oil-proof housings for the pushbuttons and contactors. Where dust and dirt conditions are severe, it is better to use a higher, 110 volt, control circuit voltage.

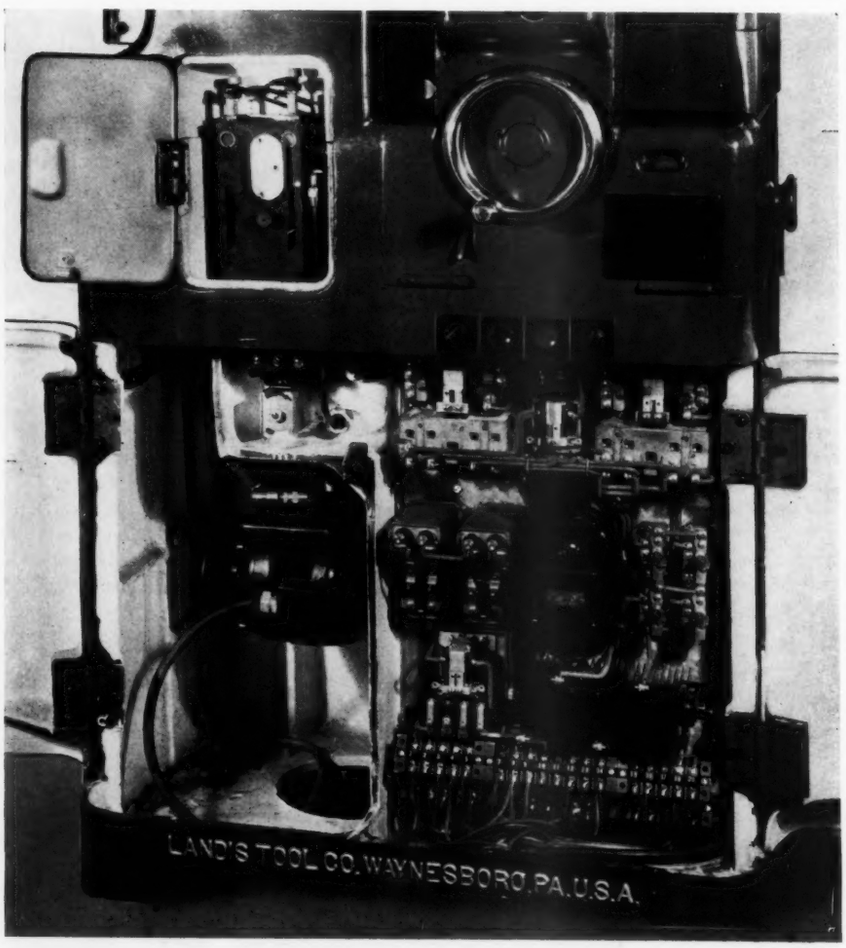


Fig. 4—Electrical circuit of the Landis Tool Company grinder is made safe for the operator by well insulated wiring and installation. It demonstrates good machine design because of the excellent accessibility to the entire electrical circuit which is so important in maintenance. In this particular machine the controls are operated at motor voltages except the mercury contacts and the sizing device which controls oscillating head motor which is supplied with d.c. by a transformer and rectifier

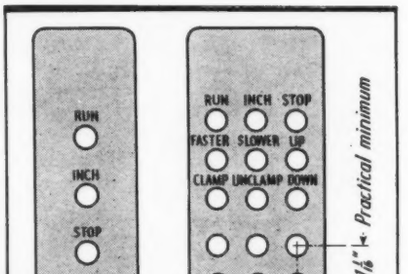


Fig. 5—Reduced voltage on pushbutton size has particular benefits for machines with complicated controls or controls mounted in a portable station

Because higher voltage control circuits operate on lower currents and can afford a higher voltage drop, smaller wiring can be used. For approximately the same conditions, a 3-amp. current flowing through 80 ft. of No. 14 wire will have the same voltage drop as a 5-amp. current through 75 ft. of No. 12 wire. Obviously, in a lower voltage circuit it is of greater importance to reduce to a minimum the number of high-current coils by using relays, and to reduce the lengths of the circuits to a minimum.

A control circuit voltage high enough to "blast" through a film of non-conducting dirt or oxide, has the accompanying disadvantage of being conducive to electrical creepage, short-circuiting and arcing. Because of this many machine tool engineers use control circuit devices of 600 volt rating and determine all their spacings and clearances on the basis of 600 volts, even though the control circuit is to operate on 110, 220 or at the most 440 volts. For the same reason, dust-proof and moisture-proof housings are used. Whereas in low voltage circuits they are used primarily to keep the contacts clean, in high voltage circuits they are used to keep out moisture and metallic

dust to prevent creepage or flashovers.

This last consideration sometimes dictates the use of a low voltage control circuit. As an example, the portable control station used on machines of the Ingersoll Milling Machine Company are for low voltage operation, 24 volts. Because the voltage is low, there never is any fear of serious consequences if the control panel gets close to the cutters and gets sprayed with oil or metallic dust. The resistance of the control circuits, including contacts and coils, is so low in comparison to the resistance of the path of leakage, that there is little fear of leakage. Nor can an arc be maintained even if a flashover does occur, and hence a flashover would have little effect on the contacts.

Sometimes special low voltage devices are required in the control circuit to perform some specific function. Low voltages are a necessity when low voltage sensitive instruments, electronic tubes or similar devices are used in the circuit. An example is the Landis Race-A-Way grinder in which the sizing device, a mercury column in a U-tube that makes contact and establishes a connection, operates on 85 volts to prevent excessive oxidation of the mercury. Another low voltage circuit on this machine, operating through a rectifier, provides d.c. power for dynamic braking of the oscillating drive motor.

The Keller-Electric type controls used on the Pratt-Whitney die sinkers and on Monarch lathes operate on 12 volts. In these machines a tracer mechanism, made up of electrical contacts which complete circuits from the low voltage supply to relays, follows a pattern. The relay in turn operates solenoid clutches which engage and disengage certain elements of the machine to give the correct motion to the spindle. Low voltage makes it possible to hold the space between contacts to a minimum to give the tracer mechanism maximum sensitivity. With lower voltages the length of arc is reduced with consequent improvement in accuracy of operation where "feeler" or "quick stop" action is used. For the same reason low voltage circuits are preferable in gaging operations which depend on "feel" for their accuracy.

Pilot and signal lights are usually low voltage bulbs having sturdy filaments of heavy wire and are of low wattage. Oilgear uses eight 24-volt lamps in an electric-hydraulic tell-tale fixture on its new Pushemall press. A transformer reduces the 440-volt a.c. motor line current to the lighting circuit. Built-in lamps and adjustable lamps are made doubly safe for the operator on many machines such as the Kearney & Trecker milling machines and Haskins tapping machines, by operating them on 32-volt power furnished by a transformer which can be mounted anywhere in the machine frame.

From the cost standpoint it is difficult to compare low voltage with high voltage control circuits. While a general statement could be made to the effect that a low voltage relay, for example, would be cheaper in cost than say a standard N.E.M.A. relay, that is only part of the story. When the additional complications caused by using low voltages are considered, the total cost of the circuit may be no less. A special portable station such as the Ingersoll mentioned above is decidedly more expensive than it would be if standard size 110-volt apparatus were used. In this case, the additional cost is far outweighed by the need for portability, proper action under the atmospheric conditions which exist, and safety. When it is considered that the controls represent only a small portion of the total cost of a machine any extra expenditures for safety or improved operation would represent only a small percentage of the total cost of the machine but adds much to its value.

If the main power source is d.c., a separate motor generator set will be needed to reduce voltage for the control circuit. A series resistor could be used but the line voltage would be present on open circuit. If a shunt voltage dividing resistor is used, there is still danger of the operator receiving full voltage unless some form of grounding is used. This is not commonly done unless electronic tubes or equipment requiring low voltage is used in the control circuit.

Conditions such as space restrictions, low voltage devices, or abnormal amount of metallic dust and moisture in the atmosphere may dictate the use of low voltage for the control circuit. But with high voltage, 110 or 220, there is more assurance of quick dependable action when the contacts are closed. There will be sufficient potential to overcome any reasonable increased resistance of poor contacts; coil and relay operation will be instantaneous and positive. But whether it be high or low voltage, the circuit must be designed to be safe.

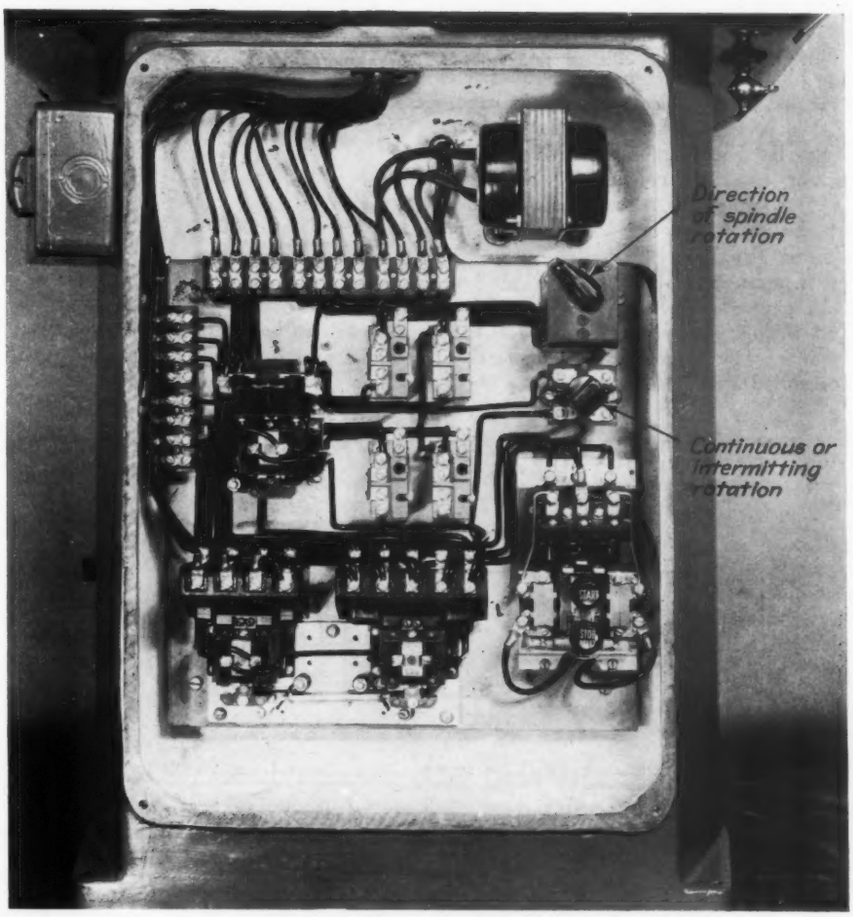


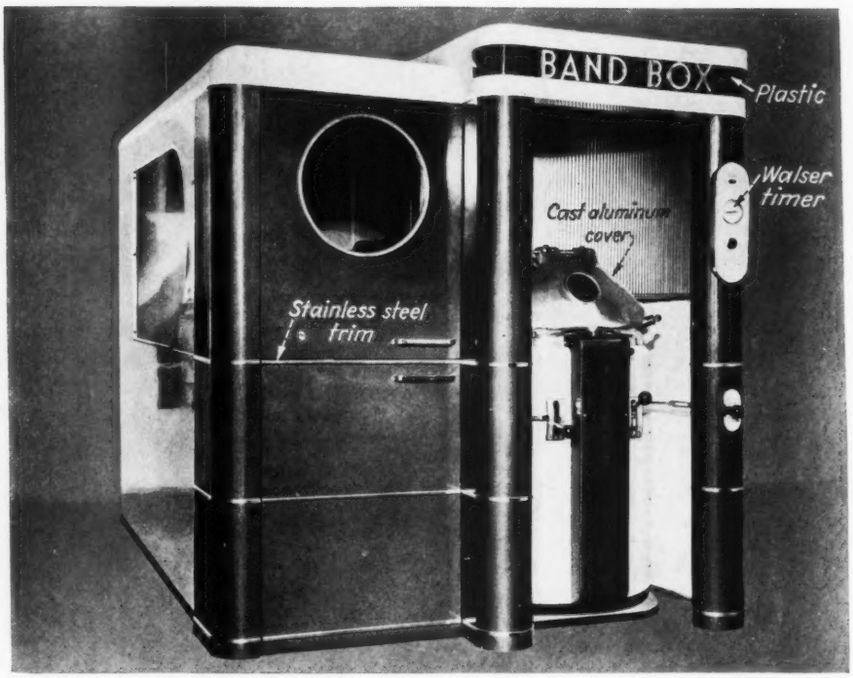
Fig. 6—Brown & Sharpe milling machines are all electrically controlled, use 220-volt transformer for control circuit when main power lines are above that. Electric equipment is housed in oil-tight compartments cast integrally in machine base. This control compartment of plain milling machine is typical

Modern Designs

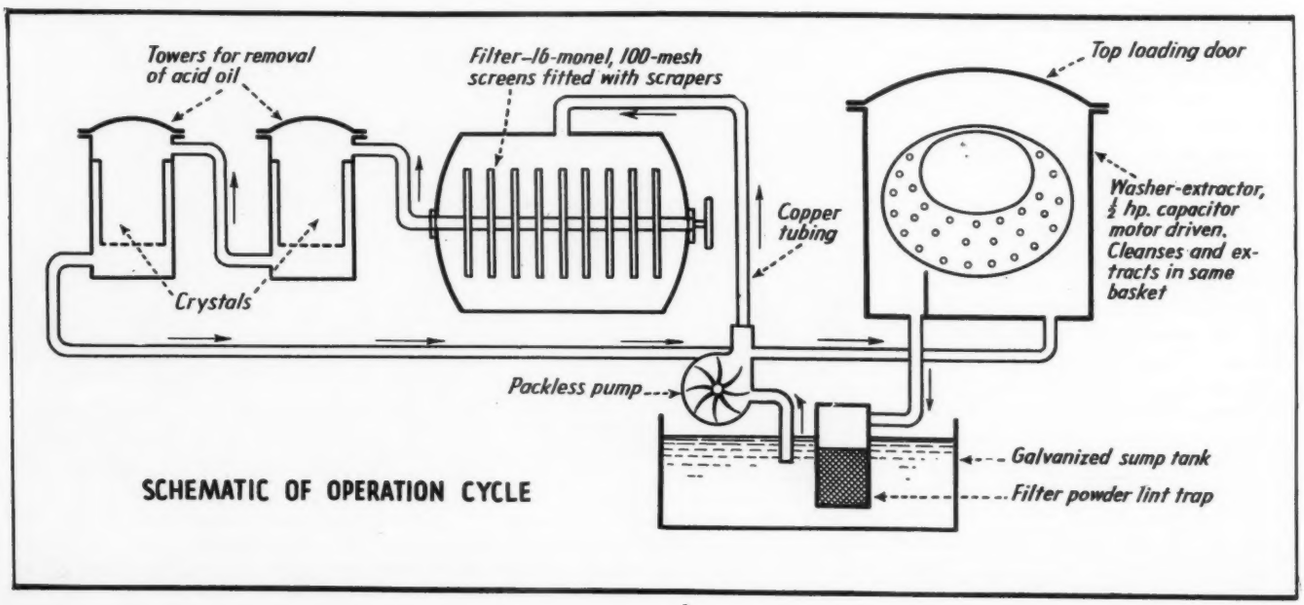
Complete Dry Cleaning Plant Fits 6 x 9 Space

Compactly housed in a space-saving chrome-trimmed steel cabinet, the new Bandbox Meteor has a capacity of 100 lb. per hr. using a continuously circulated solution of carbon tetrachloride. Fumes are exhausted through a built-in sheet metal housing which incloses a heavy-duty blower, V-belt driven from a ½ hp G.E. brushless single-phase motor. Nameplate and letters on cabinet are fluorescent plastic.

Washer-extractor is V-belt driven by a 1½ hp single-phase gear-head motor, equipped with a built-in multiple-disk clutch. Washing speed of basket is 44 r.p.m., extracting speed 800 r.p.m. Basket is drawn monel, and is divided by means of a perforated plate into two compartments. It is supported on pillow-block ball bearings mounted on machine frame. Seals prevent leakage. Filter is galvanized heavy-gage sheet metal finished in special baked enamel. Screen assembly consists of 16 circular, monel-mesh screens which are fitted with copper scraper blades. Solvent is circulated by vertical packless centrifugal pump driven by ½ hp. G.E. capacitor motor. Copper tubing and fittings are used throughout the system. Operations are automatically controlled by Walser timer.



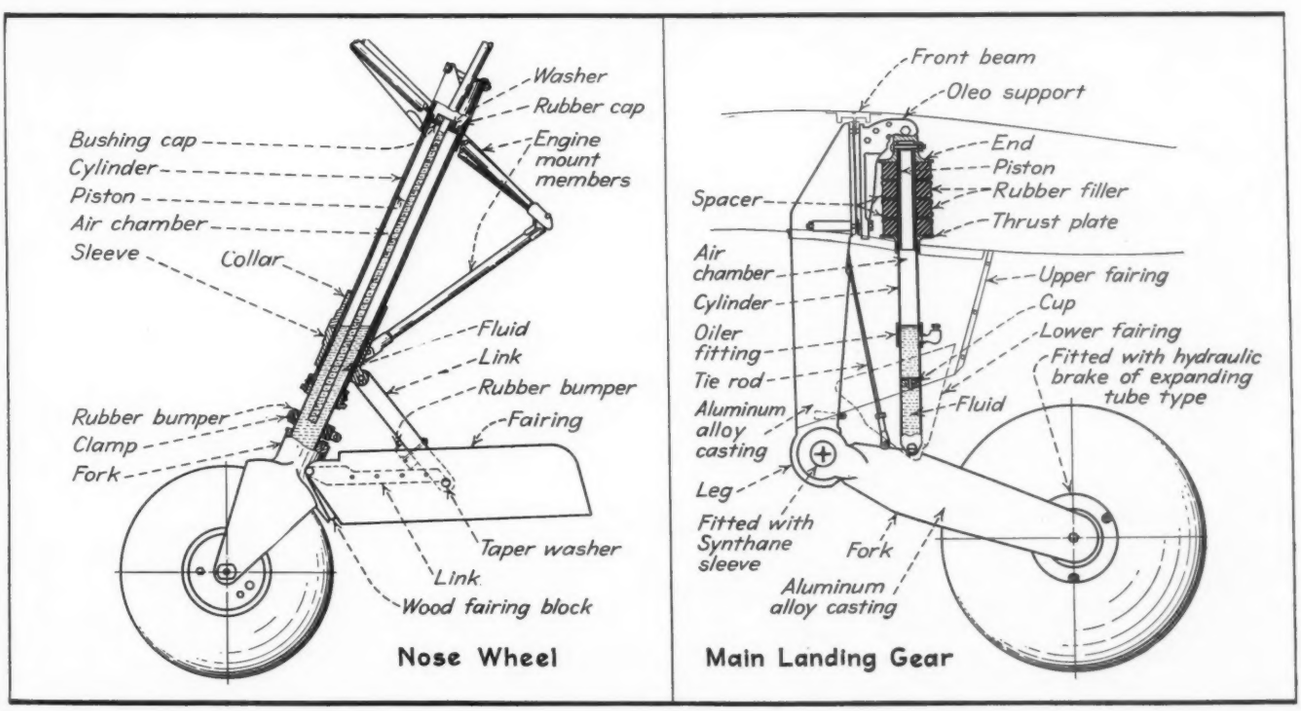
Schematic of system below shows how solvent is circulated through washer, filter and crystal towers which continuously remove undesirable oils by percolation of the solvent through activated crystals. Towers are of galvanized, heavy-gage sheet metal, finished in corrosion-resistant baked enamel.


Towers for removal of acid oil
Filter–16-monel, 100-mesh screens fitted with scrapers
Top loading door
Copper tubing
Washer-extractor, ½ hp. capacitor motor driven. Cleanses and extracts in same basket
Crystals
Packless pump
Galvanized sump tank
Filter powder lint trap

SCHEMATIC OF OPERATION CYCLE

Formed and Riveted Aluminum Sheet Construction

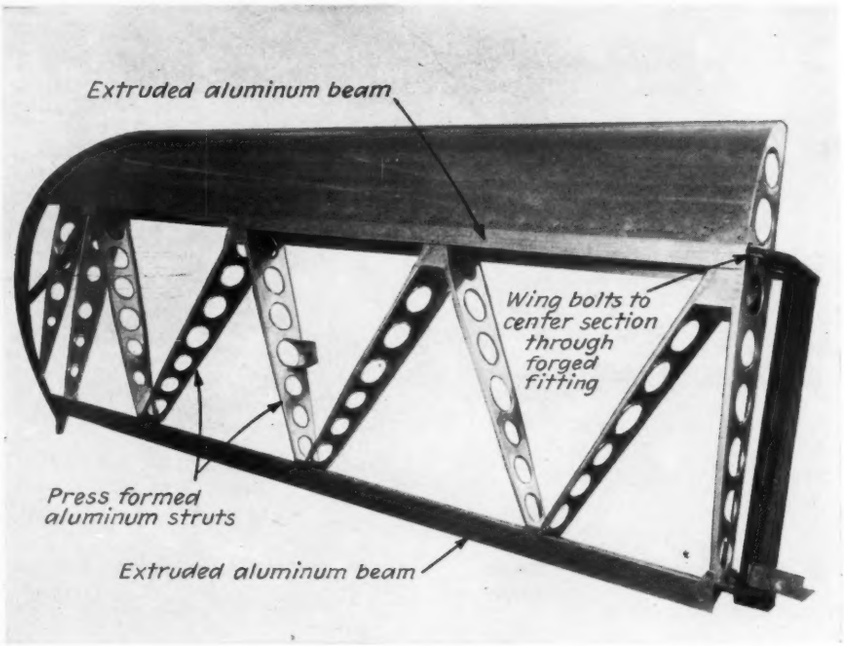
Ten years' development beginning with the pioneer design of Fred E. Weick, chief engineer of the Engineering and Research Corporation, preceded this new Ercoupe. Aim of the design was a light-weight, low-cost plane particularly suitable for private flying, having good stability, ease in handling and definite no-spin characteristics. Light weight with sufficient stiffness and strength was obtained with monocoque construction of aluminum alloys fabricated on specially developed forming and stretching machines and riveted on specially developed punching and riveting machines (described in P.E. Sept. '40, p. 393). Size, shape and location of wing and control surfaces are so planned that the plane, which is powered by a 65 hp. Continental engine, cannot be put into a tailspin.

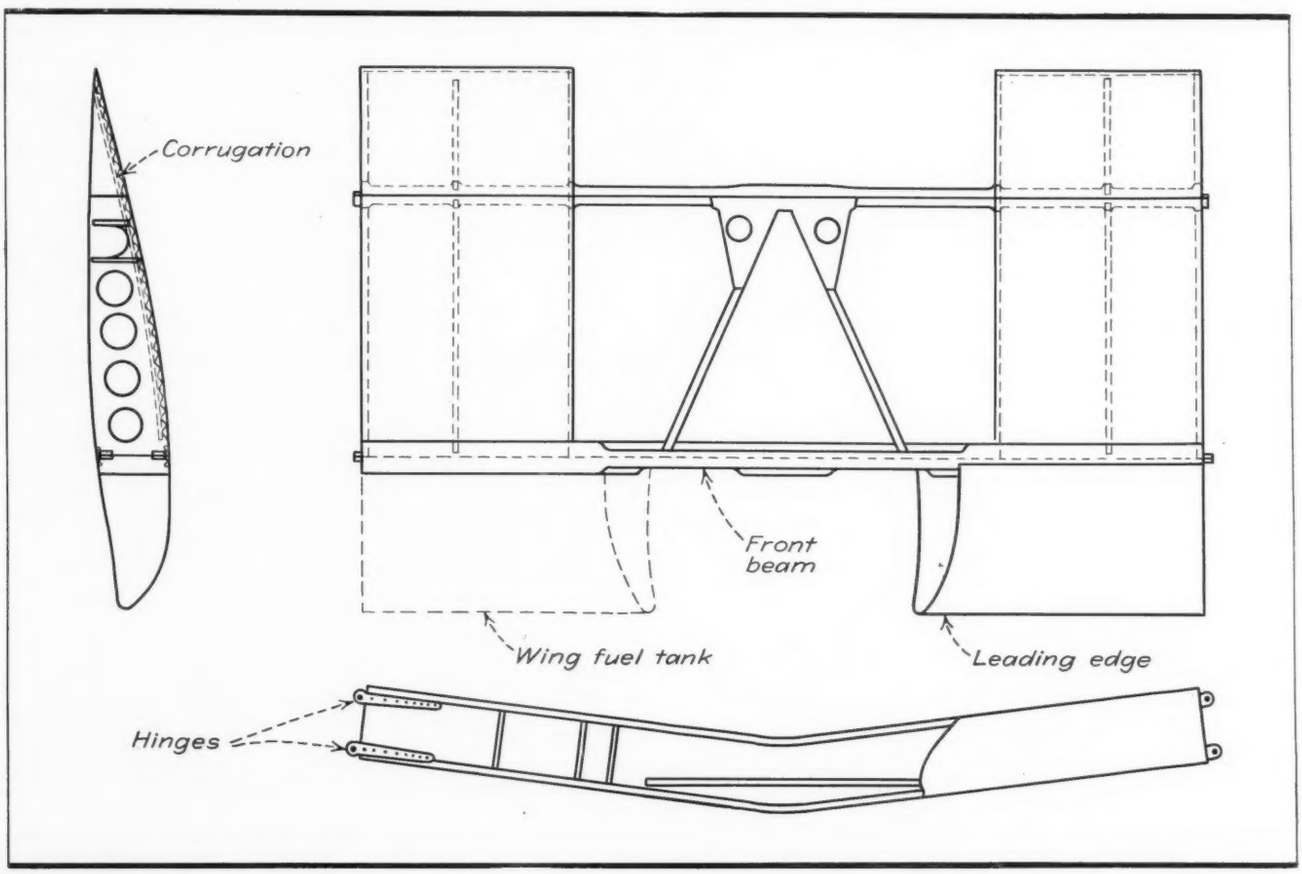


Landing gear is of tricycle type with steerable nose wheel. Forks and posts are cast of 220 aluminum alloy; wheels are Hayes magnesium alloy supported on Timken roller bearings. Hydraulic shock absorbers provide one ft. of vertical travel. Springing for taxiing is furnished by rubber compression disks for rear wheels, and compressed air for nose wheel. Rear wheels are fitted with Goodrich-Palmer expanding tube hydraulic brakes. Flexure is taken by neoprene section in hydraulic line. Steering torque is transmitted to nose wheel through nutcracker linkage. Thrust washers for wheel bearing are Synthane phenolic laminated fabric.

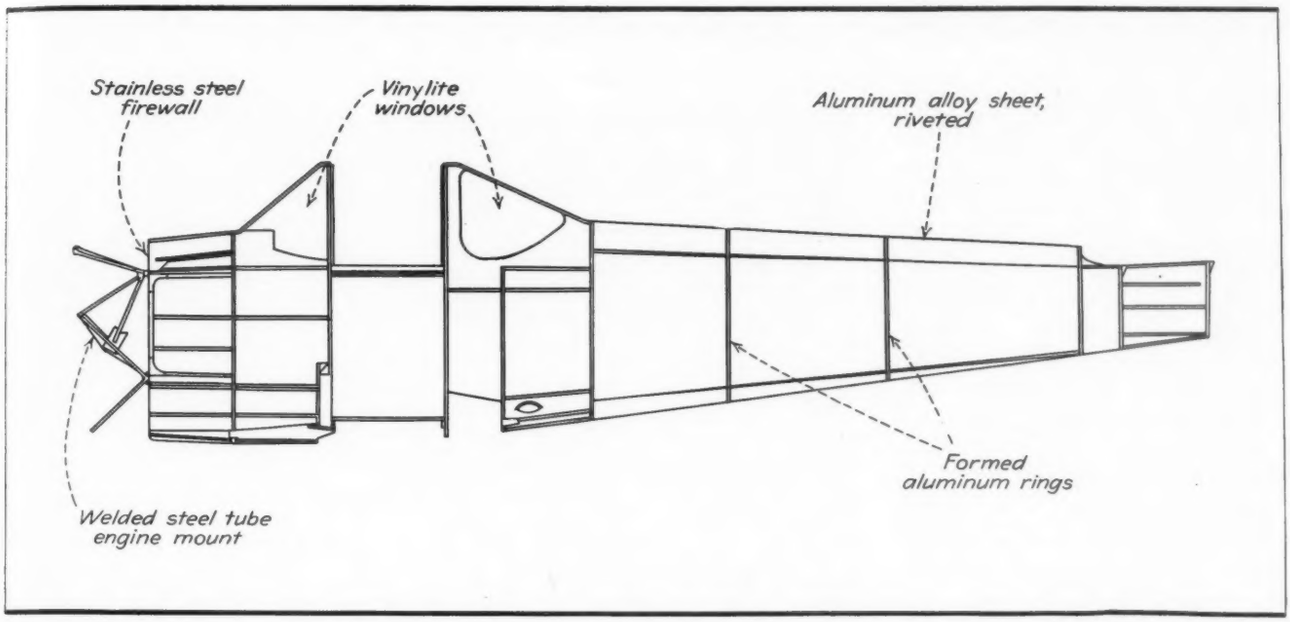
(Continued on next page)

The outer panel has diagonal ribs running between the main spar and the auxiliary rear spar. These ribs, formed of 24 ST Alclad sheet, fulfill the triple fuction of providing the drag trussing, torsional bracing, and wing airfoil form. The nose portion of the outer panel is covered with sheet aluminum from below the leading edge up around the nose and back to the main spar to assure the maintenance of the correct airfoil shape of the most critical portion of the wing. The lower surface ahead of the front spar, however, is left open so that upon removal of the fabric covering, all rivets are accessible from both sides for easy maintenance. The outer panels are supported on the center section through forged fittings and two $\frac{5}{16}$" bolts on the rear spar and two $\frac{5}{8}$" bolts on the main spar. These bolts support the entire airplane in flight. Front beam fitting hinges are heat-treated to obtain a tensile strength of 180,000 lb. per sq. in. Wings can be removed for storage.


Extruded aluminum beam
Wing bolts to center section through forged fitting
Press formed aluminum struts
Extruded aluminum beam

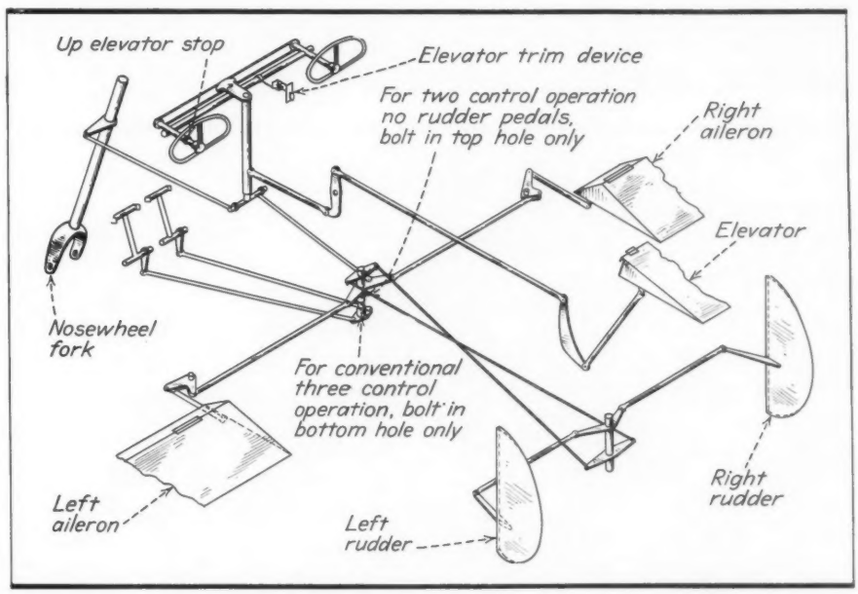


Center panel is entirely covered with 24 ST Alclad sheet, a portion of the upper surface forming a walkway on each side of the fuselage. The fillets or fairings between the fuselage and the wing influence the stalling characteristics of the airplane. The section located ahead of the main spar on the right hand side of the fuselage forms the main gasoline tank. The tank is fastened by oval head machine screws and Elastic stop nuts, the latter being permanently riveted in place on the spar flange so that the machine screws can be removed and replaced.



Fuselage is of monocoque construction composed of a simple shell of 24 ST Alclad sheet riveted to four formed oval rings of the same material. The cockpit portion of the fuselage is of semi-monocoque construction, the sheet material skin being riveted to extruded 24 ST aluminum alloy angles. This portion is built integral with the center section of the wing. The cockpit is covered with a transparent housing of Vinylite PP VS 1310 clear. The engine mount ahead of the stainless steel fire wall is a welded S.A.E. 4130 chrome-molybdenum steel tube structure, supported at four fittings projecting through the fire wall by $\frac{7}{16}$ in. AN bolts. The structure supports the engine and nose wheel.

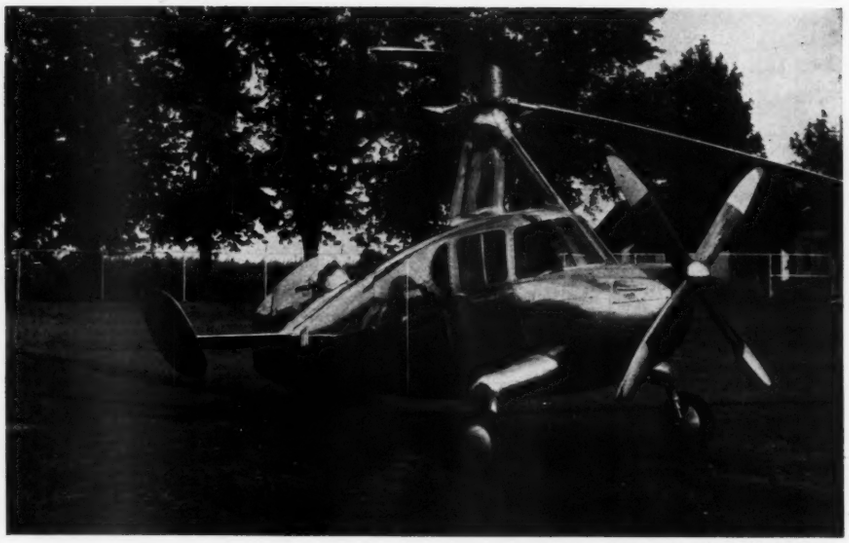
Control wheel in the cockpit not only moves the ailerons but steers the nose wheel as well, and in addition, if two-control operation is desired, the rudders are also connected to the control wheel. Ease of motion is assured by the use of a large number of ball bearings. The linkage system is free of pulleys, making use of bell crank levers, push-pull tubes, straight cables, and Fafnir ball bearings at pins. Fore and aft motion of the control wheel moves the control column under the dash with it, and the motion is transmitted back to the elevator by means of push-pull tubes and two bellcranks, one at the rear of the main spar under the seat, and the other mounted at the tail of the fuselage. Hook-up is illustrated diagrammatically. The upward travel of the elevator is definitely limited so as to prevent the possibility of maintaining the airplane in a completely stalled attitude with full power in use. Turning the control wheel turns a torque tube inside the control column by a chain and sprocket arrangement. From a lever at the bottom of this torque tube this motion is transmitted to the ailerons by means of push-pull tubes and bell cranks. Turning the control wheel also steers the nose wheel at the same time that it deflects the ailerons through a second lever at the bottom of the torque tube within the control column which is connected by a push-pull tube to a lever mounted on the



hydraulic cylinder of the nose wheel. Motion is transmitted through a nutcracker linkage, not shown, down to the fork and the nose wheel itself. With the control wheel deflected to its maximum of 180° the nose wheel will be turned 30° to one side. Rudder pedal (if used) are mounted on torque tubes, and bell cranks and push-pull tubes connect them to the control mast behind the seat. When two-control operation is desired, the rudder pedals are removed and the rudders are connected to the aileron system and are moved by the control wheel. The change from two to three control linkage is made by changing a single bolt from one location to another in the control mast back of the seat. With the bolt in the upper position, as shown, the rudder and aileron bell cranks are locked together, and the bell crank to the pedals is disconnected. With the bolt in the lower position, the ailerons and rudders are not connected together, but the rudder pedals are connected through to the rudders.

MODERN DESIGNS – Capable of Vertical Take-off

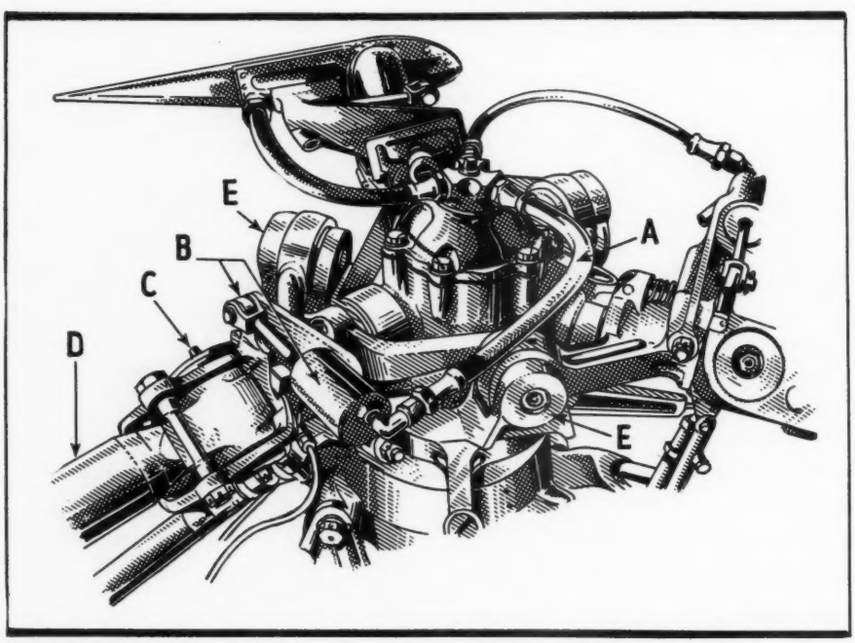
Utilizing kinetic energy stored in the rotor, the new Whirlwind autogyro is capable of jump take-offs of 15 to 35 ft. vertically, depending on prevailing wind conditions. High maneuverability both on ground and in the air, and speeds ranging from 120 mi. per hr. to hovering flight, are available in this new Pitcairn design which will have civil, commercial and military uses, particularly for aerial surveying, fire control, reconnaissance and transportation of personnel to locations inaccessible to ordinary planes.

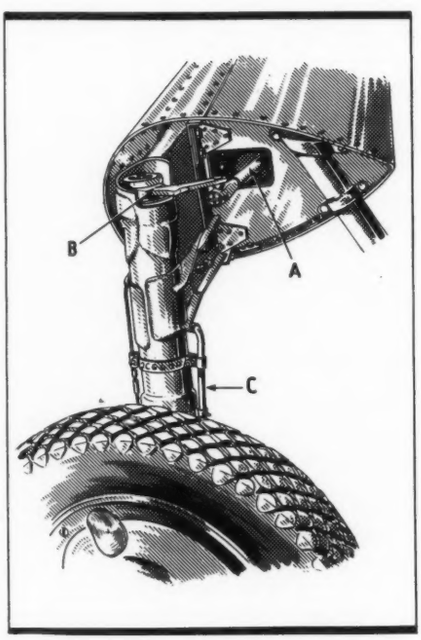


Illustrations courtesy of Aviation Magazine

Engineering features, as described in *Aviation,* are based on seven years development from the original Cierva design, and include all-metal construction, midship engine location to provide power both fore and aft as required, high pressure engine cooling, direct control of rotor-axis tilt, and steerable landing gear. Plane, compactly designed, has length of 20 ft. 5 in. and height of 10 ft. 3½ in.

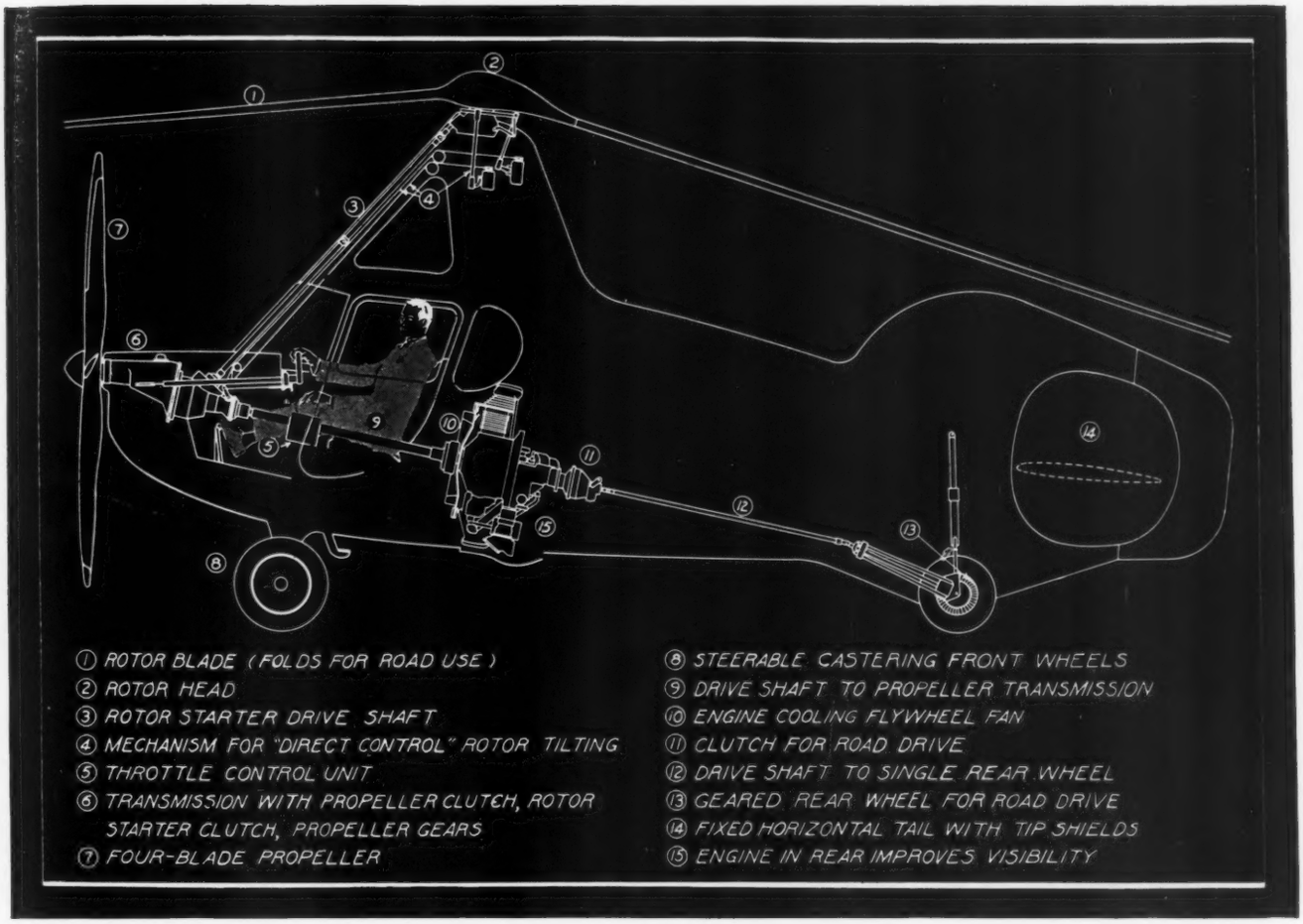
Inclosed motor advantages: increased range of vision for both pilot and passenger; power to drive the rotor-starting shaft, taken from the proper side of the engine, permits the unlimited use of the available horsepower for bringing the rotor up to speed; forced-draft cooling of the engine controlled under all conditions. Because of the autogyro can maintain flight at low speeds, motors on previous ships, where cooling depended on air speed, frequently overheated. Flywheel was designed with an integral Sirroco fan around its perimeter and a ring gear which makes possible the use of a standard automotive-type electric starter. Air is drawn through grille in nose.





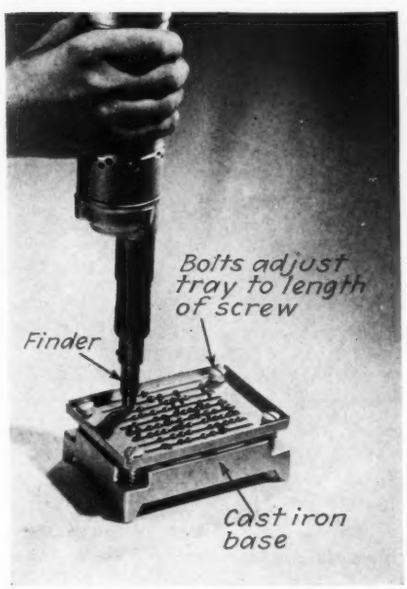
Rotor blade is attached to the hub through two hinges "*E*." The hydraulic line "*A*" forces oil into the cylinder "*B*" moving the piston which controls the pitch of the blade. "*C*" is a hinge allowing the blades to move up and down. "*D*" is the arm connecting the blade and hub. The rotor can be accelerated to 300 r.p.m. while the ship is standing on the ground. Releasing the pressure permits blade to "unscrew." Since normal flight rotation of the rotor is only 180 r.p.m., the stored kinetic energy is converted into lift.

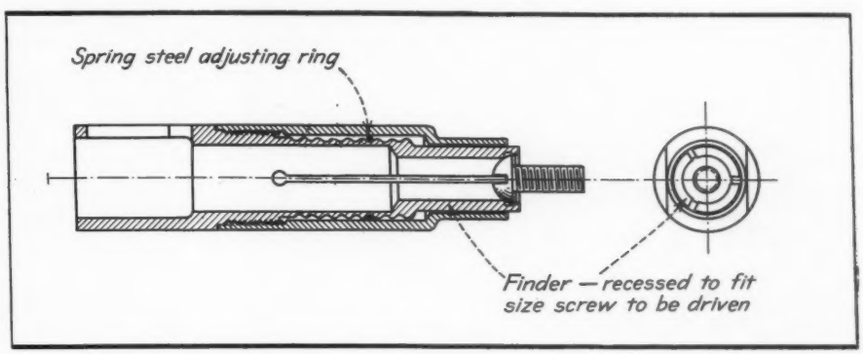
Steerable landing gear for use in maneuvering along ground. Control is accomplished through a system of tie-rods and bellcranks. Tie-rod "*A*," connected to the control wheel turns bellcrank "*B*." "*C*" is the hydraulic line to the brake.


① ROTOR BLADE (FOLDS FOR ROAD USE)
② ROTOR HEAD
③ ROTOR STARTER DRIVE SHAFT
④ MECHANISM FOR "DIRECT CONTROL" ROTOR TILTING
⑤ THROTTLE CONTROL UNIT
⑥ TRANSMISSION WITH PROPELLER CLUTCH, ROTOR STARTER CLUTCH, PROPELLER GEARS
⑦ FOUR-BLADE PROPELLER
⑧ STEERABLE CASTERING FRONT WHEELS
⑨ DRIVE SHAFT TO PROPELLER TRANSMISSION
⑩ ENGINE COOLING FLYWHEEL FAN
⑪ CLUTCH FOR ROAD DRIVE
⑫ DRIVE SHAFT TO SINGLE REAR WHEEL
⑬ GEARED REAR WHEEL FOR ROAD DRIVE
⑭ FIXED HORIZONTAL TAIL WITH TIP SHIELDS
⑮ ENGINE IN REAR IMPROVES VISIBILITY

Power and control units. Engine is a Warner Super-Scarab of 175 hp., separated from the cabin by an insulated metal bulkhead. Setting the single control handle locks the wheel brakes, sets the rotor blades at zero pitch, puts the transmission at a 2 to 1 gear ratio and engages the clutch to the rotor power drive shaft. When 300 r.p.m. speed is attained, the pilot turns the single control handle, and the ship rises vertically into climbing flight. The turning of the control handle in making the jump take-off causes the rotor blades to change from zero pitch to normal flight pitch, the rotor power drive shaft to declutch, the gear to the propeller to change from 2 to 1 ratio into 1.54 to 1 ratio and the wheel brakes to unlock.

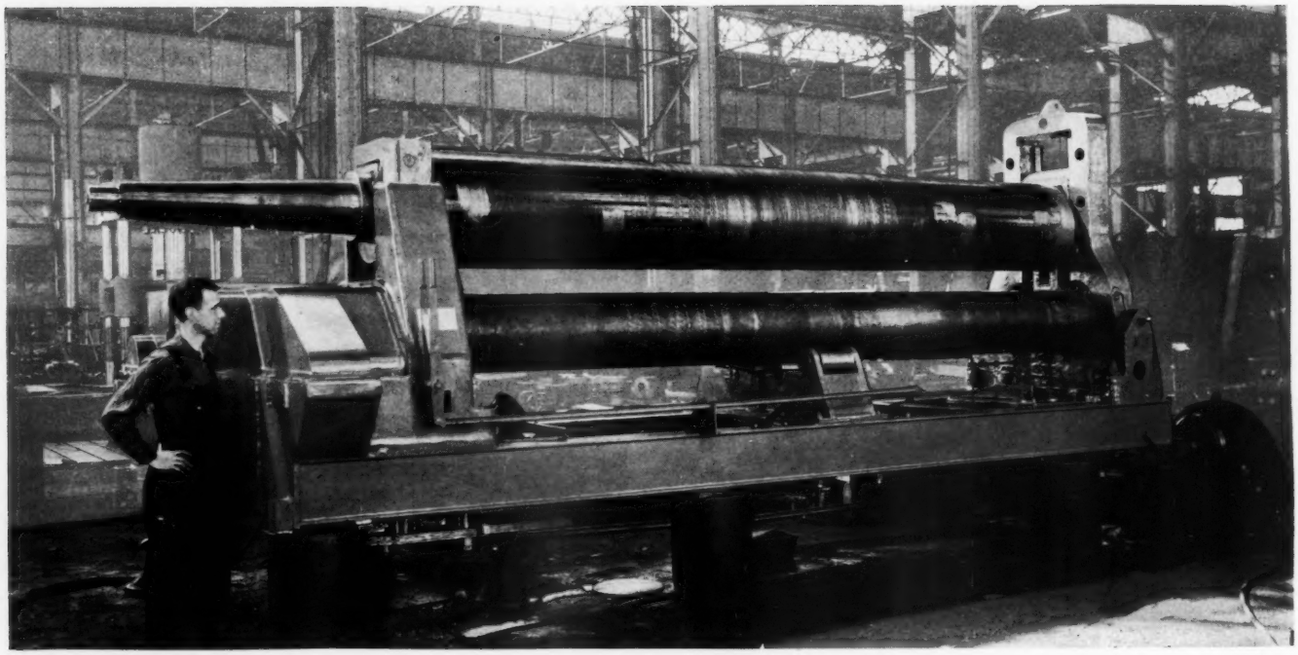
The change of the propeller gear ratio is essential to provide high static thrust and rapid acceleration to flight speed which is attained before the kinetic energy in the rotor is dissipated.





Special chuck for attachment to a power-driven tool, and a slotted tray of sheet steel, spring-mounted on a cast iron base, have been developed by the Independent Pneumatic Tool Company to reduce time in screw-assembly jobs. Chuck or finder is a hollow tube of hardened spring-steel, slotted and recessed so that it automatically grips a screw suspended in the tray. Screw slips out of finder after driving when end of finder contacts surface. Annular grooves provide seat for adjusting ring of spring steel. When ring is moved toward end of finder, tension of gripping jaws is increased.

MODERN DESIGNS–



Greater rigidity and better load distribution at joints between drive box, bed rails and inner housing was obtained in this 16-ft. horizontal bending roll by welding parts as an integral unit. Nuts and gears for screwing down the top roll are inclosed in oil-tight boxes, bolted to frame. Two control levers, shown in feft foreground, operate clutches which permit either end of the roll to be raised or lowered independently, for rolling conical shapes. Work which must be removed from machine in a direction parallel to axis of rolls is handled through drop-end housing. Machine was designed and built by Baldwin-Southwark division of the Baldwin Locomotive Works.

Swiveling electrical socket designed by Reliance Devices Company, can be rotated 360 deg. in any plane and raised 90 deg. at right angles. Shell is of drawn brass with specially designed, stamped-out top section. Bottom edge of shell, made with standard indents, incloses a heavy-coil, tempered-steel spring which presses against a metal ball in head to permit "stay put" position at any angle, and also to prevent movement caused by vibration. Unit is shown on special base.

Sterilizing agents are compactly arranged and completely concealed behind a plastic housing of simplified design in the new Sterimatic designed by the National Technical Laboratories for soda fountain use. Plastic surface is easily kept neat and clean, will not corrode or lose color. The housing is molded of ivory Plaskon by the McDonald Manufacturing Company; it is also molded in black Durez by the Remler Company. The germicide containers have molded Durez caps.

DYNAMIC ABSORBERS

FRANK L. SCHWARTZ
Department of Mechanical Engineering, Pratt Institute

STUDY of the source of excessive mechanical vibration will often show that proper balancing or redesign of a certain part or parts will reduce the magnitude of the vibration to acceptable limits. In some cases, however, because of the type of machine, nature of its function, or other impracticability, the sources of vibration cannot always be eliminated. Examples are single cylinder reciprocating compressors, reciprocating sieves, electric hair clippers, dryers of washing machines in which the clothes are not uniformly arranged around the periphery of the dryer, and many others. In these cases isolation of the vibration or the application of a dynamic absorber may be resorted to. If the annoying feature of an airborne sound accompanies the mechanical vibration, isolation of the machine by rubber, cork or spring mountings may or may not eliminate the trouble. One of the simplest methods of preventing mechanical vibrations is by use of a dynamic absorber, because parts are few in number and simple in design.

While the principle of the dynamic absorber is to create a force which is equal and opposite at all times to the force or forces producing the variation, its use (without damping) is limited, since it operates effectively at only one speed or, at best, over a narrow range of speeds. However, in a great many machines only constant speeds are available. As an example, consider a simple cantilever beam of rectangular cross-section with an unbalanced rotor revolving near the end of the beam. The beam is stiff in the direction of the longer side of the rectangular cross-section; furthermore, the vibrating force is a centrifugal one revolving in a plane at right angles to the direction of the longer side of the rectangular cross-section. Longitudinally the beam is stiff, but transversely, in the direction of the shorter side of the rectangular cross-section, it is relatively free to move. If the speed of the motor is near the natural frequency of the beam corresponding to a transverse motion, resonance will occur and excessive beam vibrations will appear, Fig. 1. An effective absorber can be made by using a smaller cantilever with a weight on its end, located at right angles to the supporting beam and tuned to a frequency close to that of the rotor.

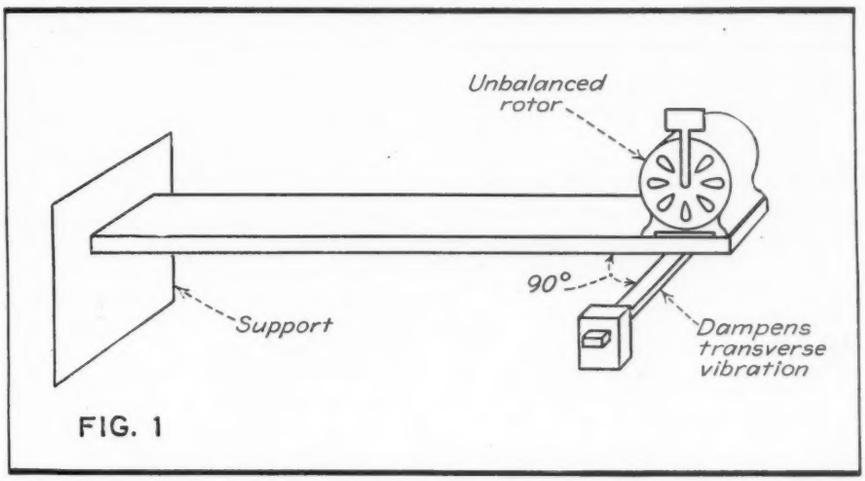


Fig. 1—Simple cantilever loaded with unbalanced rotor at end. Beam vibration dampened by small loaded cantilever placed at right angles to original beam

Before application of the absorber the resonance diagram is as shown in Fig. 2. If the pulsating force producing vibration has a frequency at or near re-

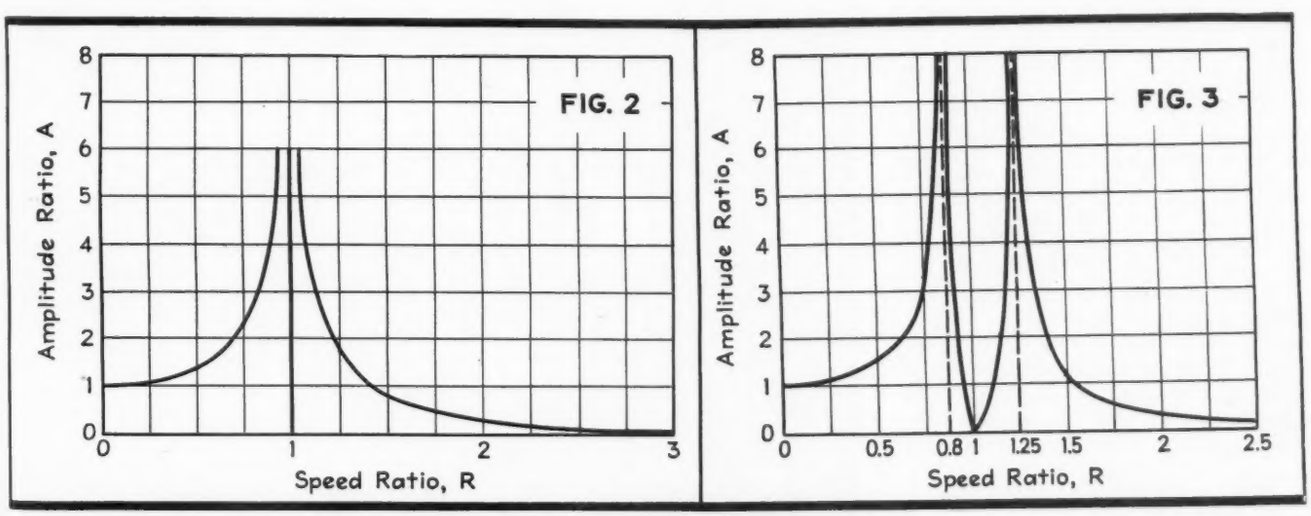


Fig. 2—Resonance diagram, before application of absorber. Fig. 3—Resonance diagram with absorber mass 20 per cent of main mass and frequency of absorber tuned to natural frequency of main mass

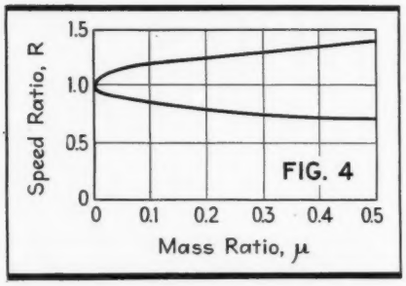


Fig. 4—Curve showing relation of mass ratio μ to speed ratio R

sonance, a large amplitude ensues. After application of the absorber to the machine the resonance diagram is as shown in Fig. 3. This curve is the plot of the equation

$$A = \frac{1 - R^2}{(1 - R^2)(1 + \mu - R^2) - \mu} \qquad [1]$$

A = amplitude ratio of main system

$$= \frac{\text{amplitude of main mass when vibrating}}{\text{amplitude of main mass under a static load equal to magnitude of pulsating force}}$$

$$R = \text{frequency ratio} = \frac{\text{frequency of pulsating force}}{\text{natural frequency of main system}}$$

$$\mu = \text{mass ratio} = \frac{\text{mass of absorber}}{\text{mass of main system}}$$

It will be noticed that the amplitude of vibration at the speed of resonance without the absorber is now zero and that over a small range of speeds near resonance the amplitude is effectively decreased. However, two new resonant speeds now appear, one on either side of the original resonant speed. The size of the absorber determines the spread of these two new resonant speeds, as shown in Fig. 4, which is a plot of the equation

$$R^2 = 1 + \frac{\mu}{2} \pm \sqrt{\mu + \frac{\mu^2}{4}} \qquad [2]$$

$$R = \text{frequency ratio} = \frac{\text{frequency of pulsating force}}{\text{natural frequency of main system}}$$

$$\mu = \text{mass ratio} = \frac{\text{mass of absorber}}{\text{mass of main system}}$$

The larger the absorber mass the wider is the spread between the two new resonant speeds. Little is to be gained by making the absorber mass more than 20 percent of the machine mass. The mass of the absorber also determines the amplitude of the absorber. The absorber amplitude is fixed by the equation

$$A' = \frac{1}{(1 - R^2)(1 + \mu - R^2) - \mu} \qquad [3]$$

A' = amplitude ratio of absorber

$$= \frac{\text{amplitude of absorber}}{\text{amplitude of main mass under a static load equal to magnitude of pulsating force}}$$

$$R = \text{frequency ratio} = \frac{\text{frequency of pulsating force}}{\text{natural frequency of main system}}$$

$$\mu = \text{mass ratio} = \frac{\text{mass of absorber}}{\text{mass of main system}}$$

It may be observed that with an absorber of small mass the amplitude of the absorber becomes large, an undesirable feature. By increasing the mass of the absorber its amplitude at the original resonant speed becomes smaller. Absorber masses from 2 percent to 20 percent may be used to best advantage, the larger the better. Practical considerations often preclude the use of a heavy damper.

Dynamic absorbers may be used to eliminate torsional vibrations as well as linear vibrations. Instead of using a linear absorber a torsional absorber is used. To reduce torsional vibration, a wheel or its equivalent having a substantial moment of inertia is supported on an elastic shaft which is fixed to the shaft of the vibrating machine. It is necessary to choose the shaft of such elasticity and a mass of such moment of inertia so that the natural torsional vibration of the absorber will be the same as the frequency of the pulsating torque to be eliminated. If the moment of inertia is too small, the amplitude of the absorber will become excessive. Equations (1), (2) and (3) hold for torsional vibrations if moments of inertia are substituted for masses and torsional amplitudes are substituted for linear amplitudes.

By use of a dashpot, viscous friction or dry friction between the absorber and main machine mass, the absorber can be utilized to dampen vibrations over a considerable range of frequencies. This type is commonly used in automotive engines.

A reciprocating table for separating sizes of gravel, Fig. 5, mounted on a table offers an example of the application of dynamic absorbers. At operating speed, around 750 oscillations per min., the table vibrated to such an extent that it was difficult to use the separator. It so happened that 750 oscillations per min. coincided with the natural frequency of the table and its separator. Rather than redesign the table, a dynamic absorber was applied to the underside of the table as shown in Fig. 5. The absorber consisted of two ten pound weights secured to a steel strip by a set screw. The steel strip was supported at the middle by a bracket attached to the table. After tuning the absorber by moving the weights to a position where the natural frequency of the absorber was 750 oscillations per min., the separator operated with practically no motion of the table.

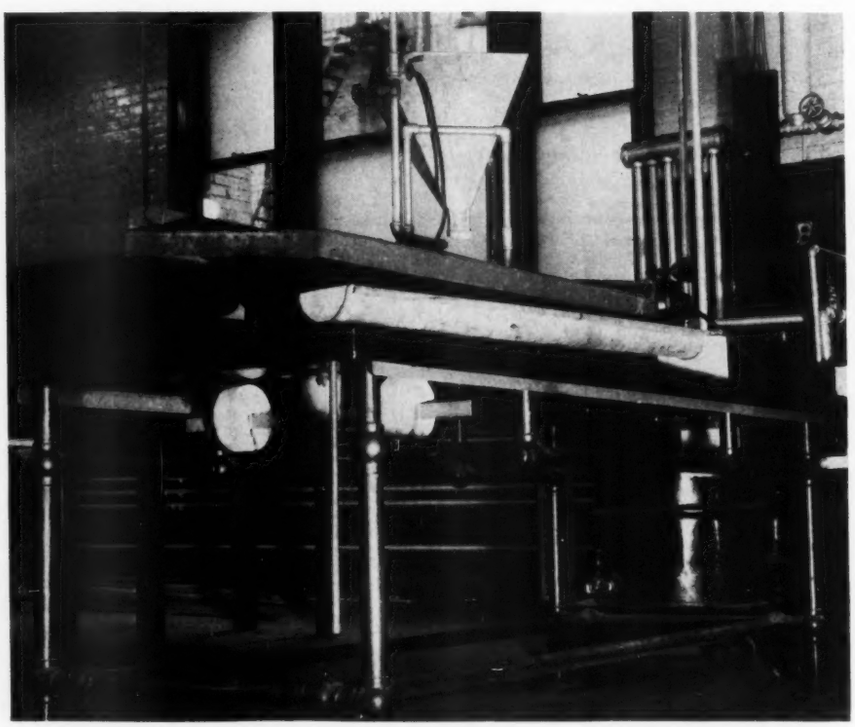


Fig. 5—Reciprocating table for gravel separation fitted with dynamic absorber

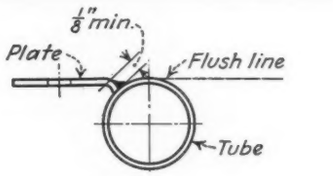
STEEL TUBE FUSELAGES – V

Detail Fittings for Controls and Armament

JAMES E. THOMPSON and T. A. LOWE
Vultee Aircraft, Inc.

THE outstanding factors in designing detail fittings for welded steel tube structures are accessibility for welding and proper balancing of cross-sectional areas at the joints. These points and their effect on production were discussed in the preceding article (P.E. *pages 28-32, Jan. 1941*) which also included typical constructions for instrument panel, air and engine control mounting. This article, concluding the series, discusses correct and incorrect fitting design for electrical equipment, armament and furnishings. This series began in October 1940 P.E.

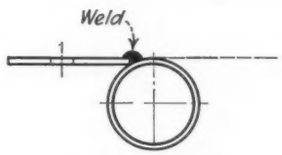
Communication and Electrical Equipment



CORRECT

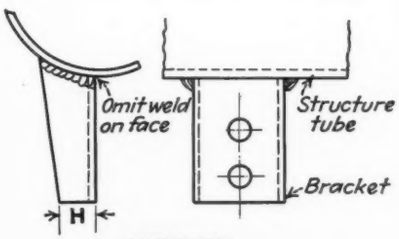
Weld will not "pile up" above the flush line with this design. Welding time will be less, and improved weld purchase obtained

FIG. 37



INCORRECT

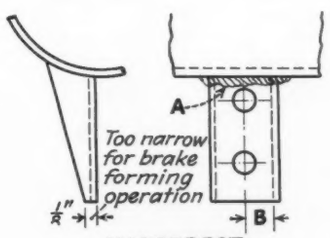
Welds on flush side have a tendency to "pile up" above the plate. A weld at the rear would avoid this condition, but would be more difficult to make, due to the deep, narrow vee.



CORRECT

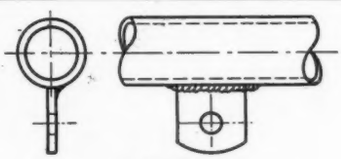
First bolt hole is located well away from weld bead, and sufficient edge clearance is provided. The flange height H should be a minimum of 1/4 in. if designed for power brake forming.

FIG. 38



INCORRECT

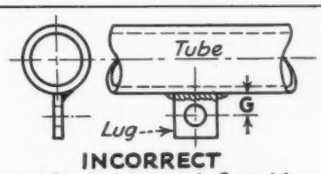
Weld bead A will interfere with bolt at first hole. Edge clearance B is insufficient as bolt hole may float ± 1/16 in. on the face of the bracket due to weld distortion. This is particularly important in cases involving a series of related brackets which must be match-drilled after welding.



CORRECT

This design has sufficient clearance. The rounded end can be formed without additional cost by using strip stock and a radius cut-off die

FIG. 39



INCORRECT

Weld must be spot-faced to allow bolt or nut to seat. G dimension should be at least 1/4 in. greater than the required spot-face radius, as 3/16 in. must be allowed for weld bead and the lug may shift the maximum of the ± 1/16 in. welding tolerance.

Operating units in the majority of this equipment are contained within metal boxes or cabinets, with circuit connections between the units being carried through conduit and junction boxes, in a manner similar to commercial electrical installations. Hence the bulk of installation provisions will involve suitable lugs and brackets for attachment of the various cabinets and junction boxes. Typical examples of these are shown in Figs. 37, 38 and 39. There will also be a few special installation provisions encountered, but these are comparatively few, and can usually be solved by an adaptation of one of the mounting provisions shown.

Armament

The majority of armament installations concerning the fuselage designer will involve the mounting of one or more synchronized machine guns to the tube structure forward of the front cockpit. The actual mounting provisions required are fairly simple, as each gun is attached at the forward end of its receiver by a trunnion assembly comprising a pivot-bolt and stirrup arranged to permit small vertical and lateral movements for sighting, and at the aft end of the receiver by a gun post assembly arranged for height adjustment. Both the trunnion assembly and gun post assembly are standard parts and require nothing more than sturdy bosses welded to the structure.

Stresses incident to machine gun operation are high, particularly in the case of 0.50 caliber guns, and it is essential that the supports for the guns either be welded directly to the basic fuselage structure, or to heavy truss members permanently welded to the basic structure. *(Continued on next page)*

Pilot's Seat

Standard military-type pilot's seat is of the so-called bucket form, made from sheet aluminum alloy and supported on two vertical guide tubes. Provision is made for adjusting the height of the seat over a wide range and an adjustable safety belt is fitted to the seat. Attachment of the seat assembly to the fuselage structure is generally made by means of lugs similar to those shown in Fig. 28, Jan. *P.E.*, holding anchor bolts passing through the upper and lower ends of the guide tubes. The installation provisions for a pilot's seat are actually quite simple as shown in Fig. 40, and it is only necessary to bear in mind that the stresses imposed on the seat and its attachment lugs are high during maneuvers—requiring that the attachment lugs be welded to the basic fuselage structure, or to a heavy truss connecting to the basic structure, and that the fittings be so arranged that the entire assembly of seat and guide tubes can be removed by simply withdrawing the four anchor bolts. Passenger seats used in commercial aircraft are made in a variety of forms, although the majority attach to support rails forming part of the cabin floor structure, in much the same manner as automobile seats. Floor support shown in Fig. 41 can be adapted to provide for installation of the majority of passenger seat designs.

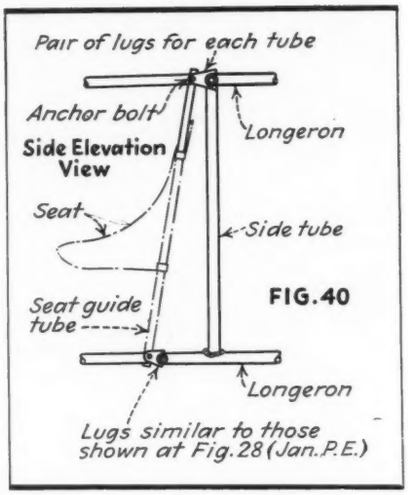
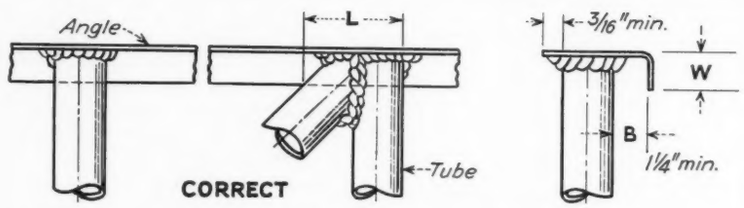


FIG. 40



*This design saves 50 percent of welding time required for the "incorrect" design, and will have less distortion from welding. Dimension **B** should be approximately equal to flange width **W** unless **B** is 5/8 in. or more. The dimension **L** is a factor of weld accessability, since width **W** should decrease as **L** increases, and vice versa.*

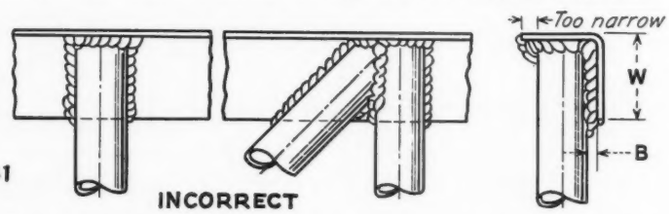


FIG. 41

*Narrow edge burns away easily, requires extreme care during welding. The dimension **B** is too narrow to allow seal-welding the tubes without "piling" the weld bead, which increases welding time, slows production and increases warpage. If design will not permit a minimum **B** dimension of 5/8 in., and where **W** must be 5/8 in. or more, it is best to eliminate gap **B** and fit tube snug to angle flange*

Furnishings

All fuselage equipment items that do not properly belong in any of the classifications discussed are included in this group. The actual mounting requirements are as varied, but it will be found that application of logical reasoning to each problem will permit adaptation of some one of the various brackets, lugs and clips shown here. Typical furnishings provisions are shown in Figs. 41 and 42. A large number of furnishings installations involve the design of welded support assemblies intended for bolted or pinned connection to the basic structure. In Fig. 43, below, is shown a typical telescope tube splice, with the simple 30-deg. scarf splice indicated as the preferable form. The fish-mouth type of splice may be used where length is to be saved, but is less desirable than the simple scarf splice.

A group of typical welded steel tube terminals, together with a discussion of the relative merits of each, is included in Fig. 44, on the following page.

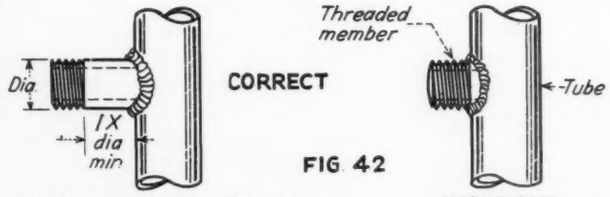
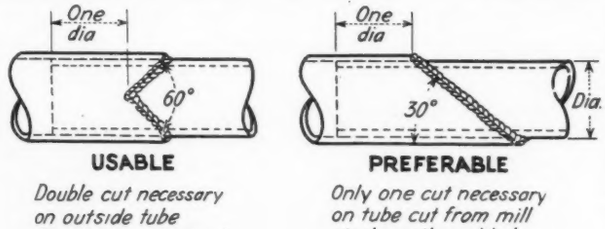


FIG. 42

2X dia permits threading before welding without danger of thread distortion during welding. Nipple may be either threaded from tube or bar stock - providing that tube has a heavy wall, or that bar stock does not exceed 7/8 in dia., unless rough drilled before welding

Threaded part will distort if threading is done before welding; short length of nipple makes threading after welding impractical



Double cut necessary on outside tube Requires more torch manipulation than other type because of two corners

Only one cut necessary on tube cut from mill stock, easily welded

FIG. 43

TYPICAL WELDED STEEL TUBE TERMINALS

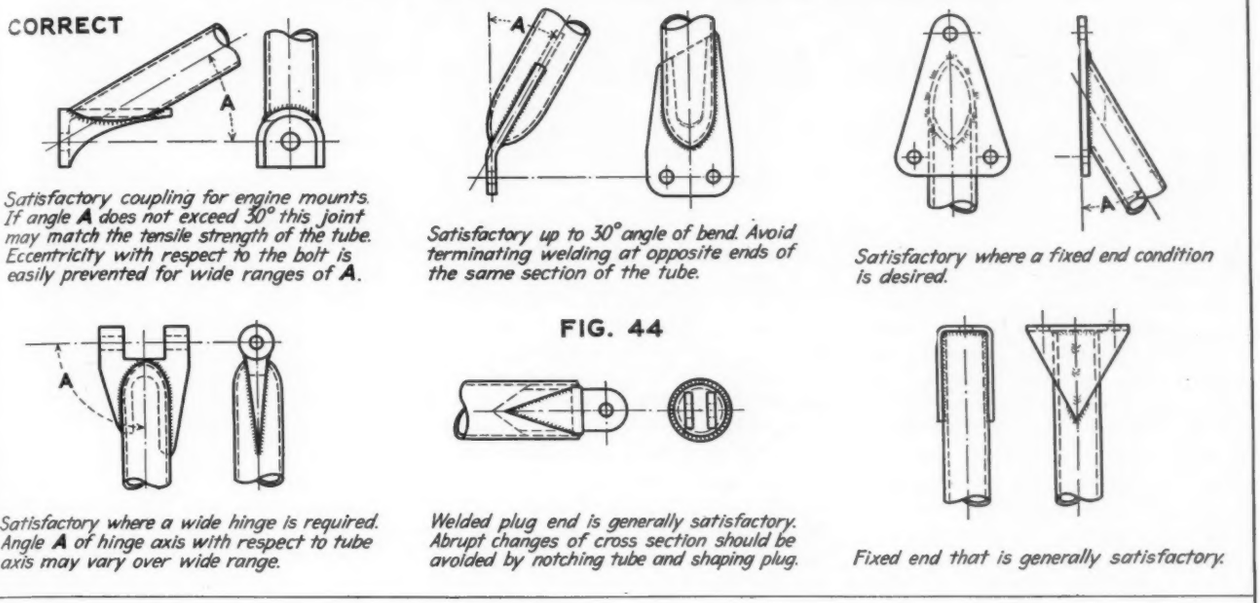

CORRECT
A
Satisfactory coupling for engine mounts. If angle A does not exceed 30° this joint may match the tensile strength of the tube. Eccentricity with respect to the bolt is easily prevented for wide ranges of A.
A
Satisfactory up to 30° angle of bend. Avoid terminating welding at opposite ends of the same section of the tube.
A
Satisfactory where a fixed end condition is desired.
A
Satisfactory where a wide hinge is required. Angle A of hinge axis with respect to tube axis may vary over wide range.
Welded plug end is generally satisfactory. Abrupt changes of cross section should be avoided by notching tube and shaping plug.
Fixed end that is generally satisfactory.
INCORRECT
Requires an excessive amount of cold working and too many welding operations.
Pinched end, even with suitable reinforcing sleeve, may crack at the bend as a result of cold working or fatigue.
Tube cracks liable to occur here
Has unsatisfactory resistance to fatigue and moments caused by load of adjoining parts.
Spacer
Not strong in compression. In heavy service it fails by crushing under spacer.

FIG. 44

General Design Considerations

From the foregoing it can be seen that the detail fittings required for installation of equipment and furnishings items fall into six basic classifications: (1) lug; (2) bracket; (3) stirrup; (4) socket; (5) boss; (6) rail or channel. Study of the "incorrect" examples shown will reveal that the factors rendering these undesirable are lack of proper consideration of: (1) weld access; (2) joint balance; (3) welding tolerances; (4) stock allowance; (5) drainage; (6) sealing of tubes; and (7) practicability of fabrication. If proper attention is given to these general factors the designer will find the creation of practical welded fittings comparatively simple.

In the case of the tube splice shown at Fig. 43, a somewhat different application of the joint balance factor exists, as herein it is desirable not only to select tubes which have a reasonably similar wall thickness, but also to select a wall thickness for the outer tube that will permit a neat slip-fit for the inner tube. If this is done there is no necessity of machining contact surfaces of either tube prior to welding, and alignment and concentricity between the tubes will be taken care of without the necessity of elaborate tooling or jigs.

Stock allowance, in the sense that it is used here, has a dual function. It involves the allowance of stock sufficient to permit hole centers to "float" at least $\frac{1}{32}$ in. in any direction with relation to the outside edges of the part and still have sufficient edge distance or clearance after welding. Also, the stock allowance should be sufficient in all cases to permit welding without danger of burning away thin projections or "ears." This factor is shown in many of the "incorrect" examples, and while it is possible to weld very thin projections, this practice is undesirable from a production standjoint as special care must be used to protect the members from burning during welding.

It is absolutely necessary to avoid pockets, and the like restricted areas, wherein moisture might be trapped and corrosion occur, and the factor of providing adequate drainage should be considered during the design of welded fittings. This is particularly important in the case of military airplanes wherein standard maintenance procedure involves steam-cleaning of the majority of the airplane structure at regular 30-day intervals.

Inside surfaces of tubular members must be coated with a corrosion preventative, usually boiled linseed oil, and this requires tubular structures to be designed with sealed ends for retention of the oil film. Standard procedure for the treatment of tube interiors involves drilling small holes in locations which will permit circulation of heated oil throughout the interior of the tube member or structure. Holes drilled in exterior surfaces for this purpose are closed after oiling by drive screws or other suitable means.

Designing for simple, practical fabrication is important as nothing slows down production more than the necessity of elaborate, complicated tooling, which in most cases can be avoided.

DESIGN OF Co–Cr–W PARTS

For Abrasion, Heat and Corrosion Resistance

R. L. LERCH
Haynes Stellite Company

ALLOYS of cobalt, chromium, and tungsten in the form of high-speed metal-cutting tools, and also in welding rods for hard-facing metal parts which are subjected to abrasive wear, are well known. In recent years, however, these alloys in the form of special castings and forgings have been developed to meet the demand of other services where conditions of severe abrasion are present, often accompanied by corrosion or heat or by both.

Cobalt - chromium - tungsten alloy specialties are made to the designer's specifications, the parts are cast to close tolerances, then ground, lapped, or polished to the required degree of surface finish. Castings as small as phonograph needles and as large as 10-lb. punches are made from one of these alloys. Forged or rolled products, such as cutting-machine knives, are hot-rolled from one of the "softest" grades of the alloy (Brinell hardness, 375-425), but the majority of products are cast of the harder grades. Some specialties are fabricated into composite parts, wherein the alloy is brazed to a steel base in a manner such that the alloy surface is exposed to the abrasive or corrosive conditions to be encountered, yet the steel forming a large percentage of the volume of the part, serves as a tough strong backing. The cost of the part is also reduced by using steel as a backing.

In many applications, because of the inherent hardness and high abrasion resistance of the cast cobalt-chromium-tungsten alloys, solid castings of these alloys have replaced special steel cast parts.

The greater hardness possessed by the cast alloy—from 4 to 8 points on the Rockwell C scale—than that of the hardest standard grade of hard-facing alloy in the as-welded condition, often justifies specifying castings in place of steel parts hard-faced with a coating, edge, or point of welded cobalt-chromium-tungsten alloy. Castings also have a longer wearing life than hard faced parts. The wearing surface of solid cast parts also has a backing which will not mushroom under impact.

Physical properties of the common alloys are given in Table I. An important physical property, as shown by curves in Figs. 1 and 2, is the alloy's retention of hardness at temperatures above 600 deg. C. or 1,112 F. This means that surface layers of the material remain hard and resistant to abrasive wear when heated to high temperature by friction and pressure. As the alloys are practically unaffected by heat-treatment, their recovery hardness after being heated into the red-heat range and then cooled to room temperature is practically constant with respect to temperature.

The values shown in Fig. 1 were obtained by subjecting ⅝-in. square samples to the temperature indicated for ½ hr. The hardness values were then measured at these temperatures. These same samples were then allowed to cool to room temperature and the hardness, as indicated in Fig. 2, was remeasured after sufficient time had elapsed to assure their becoming thoroughly cooled.

The cobalt-chromium-tungsten alloys also possess excellent resistance to corrosion from many of the commonly-used chemicals. Penetration resistance data of the cobalt-chromium-tungsten alloys are listed in Table II, the values are the results of laboratory tests on some of the most widely used grades. All results are expressed as the rate of penetration in inches per month, calculated from loss of weight after a 15-hr. test run. The concentration of the solutions are expressed as percentage by weight.

It should be remembered when using the values of physical and chemical properties and penetration-test results, that they are averages and average ranges obtained with a limited number of specimens. Slight variations from the values given may sometimes be observed in a single specimen. The

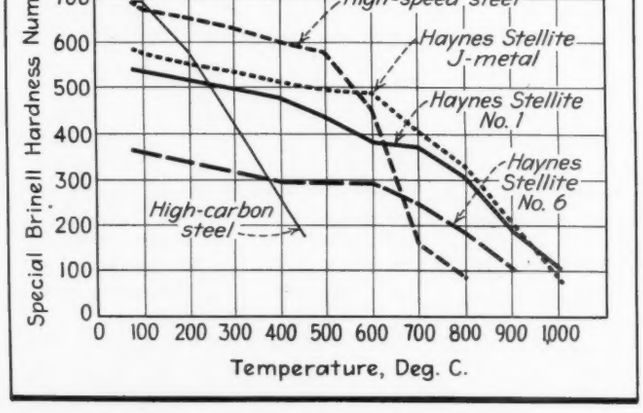


Fig. 1—Hardness of cobalt-chromium-tungsten alloys, showing retention of hardness above 600 deg. C. (1,112 F.) temperature

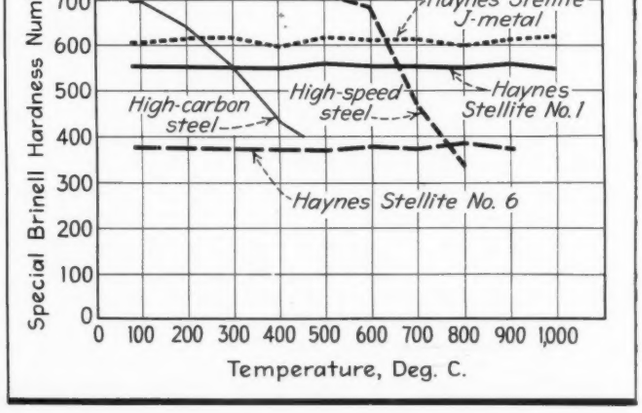


Fig. 2—Recovery hardness after cooling from temperatures up to 1,000 deg. C. (1,832 F.) of samples tested for Fig. 1 data

data do serve, however, as a guide for the engineer or designer when planning to use these materials in proposed equipment.

Surfaces of cobalt-chromium-tungsten alloy, when polished or lapped, take a high mirror-like finish which is not destroyed by atmospheric action or by many other agents that corrode some metals.

The permanence of the polished surface makes these alloys desirable materials for reflecting surfaces. Reflectors for scientific instruments are fabricated from the cast or rolled alloy. Mirror surfaces of this material reflect 68 to 83 per cent of light, depending upon the wave length. While the reflectivity values are somewhat lower than those for silver, these alloys are often more suitable because of their greater resistance to scratching and tarnishing.

Another property of these alloy surfaces is a low coefficient of friction. The average coefficient of friction of dry, polished surfaces, measured by the angle of repose is 0.11 to 0.13; for ground surfaces, the coefficient is 0.13 to 0.15. Because of these low values pump packings last longer when in contact with finished alloy surfaces than with ordinary rod surfaces, also less heat is generated. Wherever lubrication is impossible or unreliable, the low coefficient of friction and freedom from corrosion of these alloys, combined with their ability to take a high polish and retain it, are of great value. Bushings of many sizes and shapes are made of these alloys because of improved wearing qualities. These alloys working against case-hardened steel on bearing surfaces have given excellent results.

Bushings for coal stokers and roller guides for hot steel in steel mills are other parts made of cobalt-chromium-tungsten alloy to withstand abrasion and heat. Another specialty casting exposed to continuous high temperatures is a "burning element" used in a machine for stripping the insulation off covered wire. In all these instances, the use of these alloy parts has solved difficult problems.

A common method of attaching specialty alloy parts to steel is by brazing; wear strips for driving, pilot, and boring bars are typical examples. Welding is sometimes used to make composite parts such as pump rods; cast alloy rods for taking the wear can be welded onto either Monel or steel rod extensions. Electric butt-welding is also employed for fabricated steel and alloy parts. Silver-soldering is employed to attach rolled alloy shielding strips to the blades of low pressure steam turbines.

(Continued on next page)

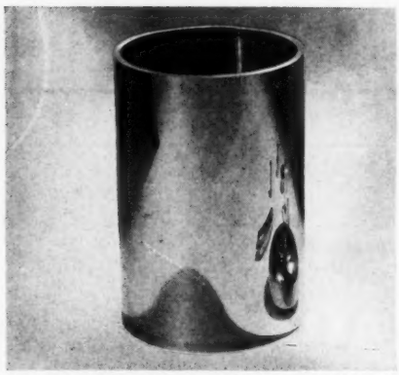
Table I — Physical Properties of Cobalt-Chromium-Tungsten Alloys

Property	"Haynes Stellite" Alloy	
	Cast J-Metal	Rolled No. 6 Metal
Specific gravity, g. per cu.cm	8.76	8.38
Melting point, deg. C	1,270	1,275
Tensile strength, lb. per sq.in	65,000	130,000
Elongation in 2 in., percent	0	2
Hardness, Rockwell C	61	40–45
Magnetic permeability at 200 oersteds	less than 1.2	less than 1.2

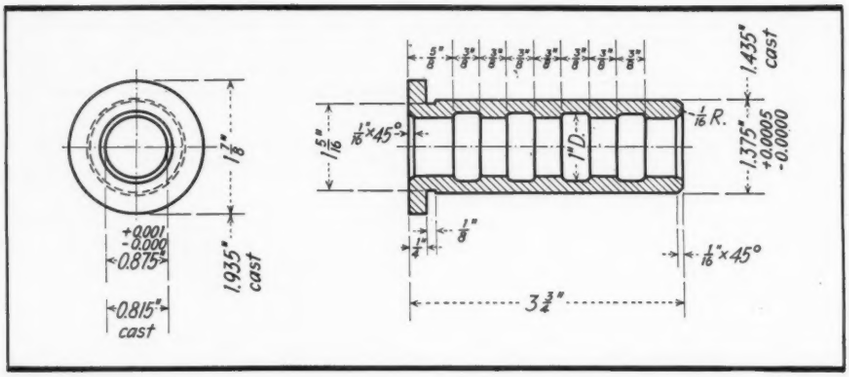
Table II — Chemical Properties of Cobalt-Chromium-Tungsten Alloys

Test	Solution	Temp.	Penetration Inches per Month "Haynes Stellite" Alloy	
			No. 1	No. 6
In wet chlorine*	Saturated vapor	Room temp.	Not measurable	0.026
In sulphuric acid	10%	Room temp.	Not measurable	0.00034
		Boiling point	0.019	0.541
In sulphuric acid	77%	Boiling point	0.102	Sample destroyed
In nitric acid	10%	Boiling point	0.0003	Not measurable
In nitric acid	Concentrated	Boiling point	0.022	0.172
In hydrochloric acid	10%	Room temp.	0.002	0.018
		Boiling point	0.287	0.176
In hydrochloric acid	Concentrated	Boiling point	0.036	24.0
In phosphoric acid	30%	Boiling	0.0017	0.00014
In acetic acid	10%	Boiling	Not measurable	0.00024
In acetic acid	Concentrated	Boiling	Not measurable	0.0003
In ferric chloride	10%	Room temp.	Not measurable	0.0095
		Boiling point	0.0063	0.172
In ferric chloride	30%	Room temp.	Not measurable	0.051
		Boiling point	0.10	0.575
In cupric chloride	10%	Room temp.	Not measurable	0.0081
		Boiling point	0.069	0.243
In cupric chloride	30%	Room temp.	Not measurable	0.032
		Boiling point	0.106	0.777
In ferric sulphate	10%	Room temp.	Not measurable	0.0001
		Boiling point	Not measurable	0.00017
In sodium hydroxide	30%	Boiling point	0.0010	0.0037
In potassium bichromate	20%	Boiling point	Not measurable	0.00017

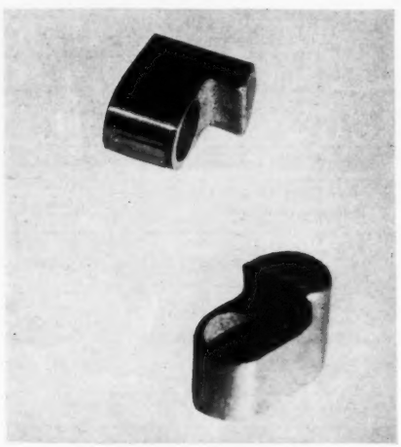
* Samples suspended in sealed bottle through which chlorine gas is constantly bubbling.



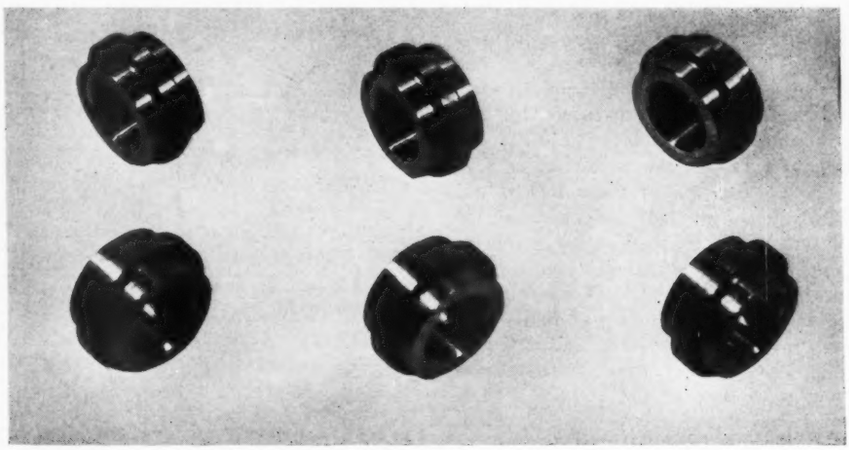
Cored casting cast to close tolerances so that internal finishing operation is not required. Finished surface is obtained by grinding.



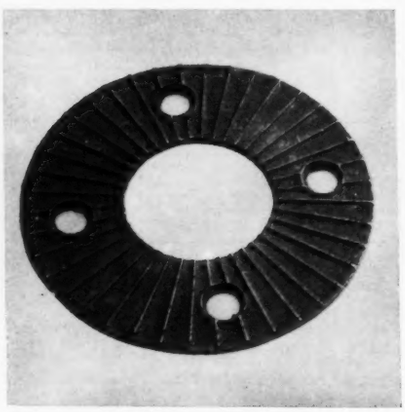
Cast bushing with cylindrical core having necks, large diameters of which are as-cast, small internal diameters are finish-ground to dimension. Designed with a minimum of finished internal surface to shorten grinding time that would be required by a bushing with straight core.



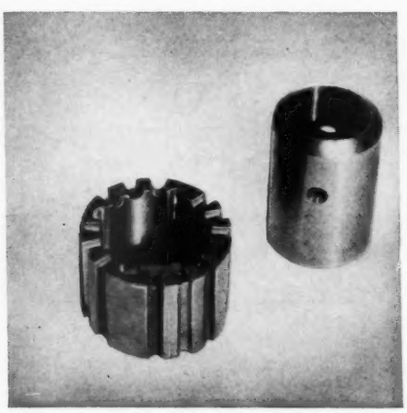
Can machine parts cast of wear-resistant cobalt-chromium-tungsten alloy to obtain long life at high speeds. Reduction in machine downtime makes use of alloy parts economical. Alloy specialties are suitable for many machine parts subjected to abrasion.



Alloy valve seats for ball-type valves installed in oil well pumps and allied equipment are subjected to the corrosive action of sulphur compounds contained in the crude oil, and also to the abrasive action of sand carried by the oil. Cobalt-chromium-tungsten alloy cast parts give long service. These alloys, because they are resistant to both abrasion and heat, are also used in services where abrasion is combined with heat in services which with most metals increase severity of the wearing action.

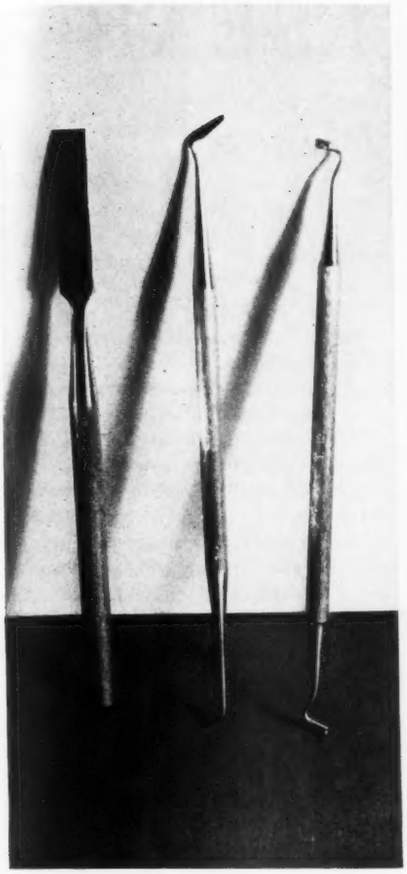


Teeth for sewage comminutors must be resistant to both corrosion and abrasion. Several dozen of these intricately shaped castings shred the material as it passes through the comminutor.

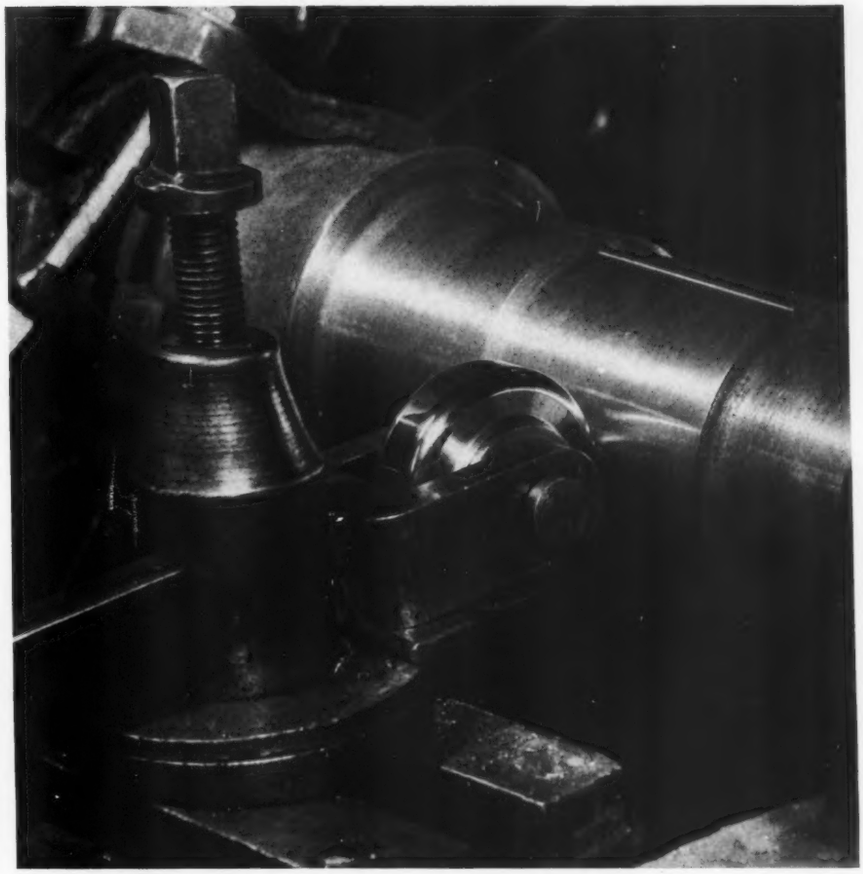


Alloy sleeve used on a 12 in. strainer bearing, which resists the corrosive action of solutions being strained and also the abrasive action of particles passing through the strainer.

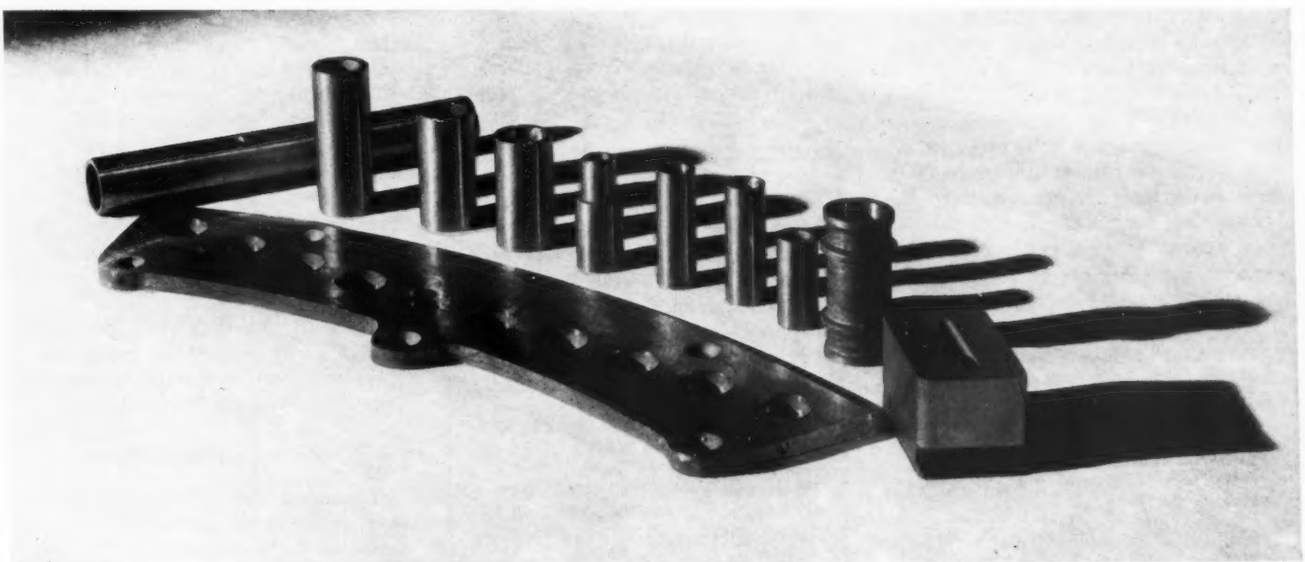
Cylinders and piston for babbitting machines are a typical example of heat-resistant parts. These parts resist the heat and corrosive actions of molten babbitt in a casting machine.



Forged alloy dental instruments are corrosion-resistant, easy to clean and stainless. The alloy possesses sufficient strength to permit the instruments being made with thin sections.



Burnishing roller made of cast cobalt-chromium-tungsten alloy. Surfaces of this alloy when polished or lapped, take a high mirror-like finish which is not affected by the atmosphere. This property has led to the use of the alloy for burnishing tools which impart by rolling under pressure a smooth hard surface to car axles and locomotive crank pin journals.



Core molds, dies and other parts used in dry cell battery manufacture, cast from cobalt-chromium-tungsten alloys in order to resist wear and corrosion, have been used for some years. The alloy is so highly resistant to chemical action that in some applications the parts retain a high polish and smooth surface even after years of such service. Like the battery mix knives which must be finished to close tolerances and retain these tolerances for satisfactory manufacturing operations, most of these parts are subjected to abrasion and corrosion.

AIRCRAFT DESIGN RESEARCH

A Case Study on Training Planes

NORTH AMERICAN AVIATION, INC.

WHEN it is considered that a typical training plane may consist of 104,233 separate parts—1 motor, 22,170 piece parts, 8,211 nuts, 2,871 bolts, 5,157 screws, and 65,823 rivets—it is not hard to believe that from 6 to 8 percent of the total factory payroll was spent on engineering research and testing. For that is the figure given by North American Aviation, Inc., in their analysis for PRODUCT ENGINEERING of engineering costs and procedures for a new two-place advanced training plane design. Although generalizations on the topic of aircraft research and design are somewhat less reliable than the weather, certain basic procedures, facts and figures will be outlined in this case study. But it must be understood that divergence from these procedures is more often the rule than the exception. All data given in this article are for the aircraft only; no attempt is made to include engineering costs for the aircraft engine.

To present an overall figure, total engineering time was 7 percent of the shop labor hours for an order of 200 training airplanes. If the same airplane were built in a quantity of 1,000 instead of 200, engineering hours would probably drop to about 2 or 3 percent of total factory labor hours—a decrease which is of considerable significance as the defense program leads to larger orders. In these percentages, only those factory hours directly charged to the contract are included.

Of every 100 men employed on this contract, 8 are engineers. The complete percentage breakdown is:

Engineers	8
Service and management	16
Machinists	7
Welders	3
Sheet metal workers	16
Riveters	19
Pattern, die and toolmakers	9
Inspectors	3
Fabric stitchers	2
Painters and finishers	2
Mechanics and assemblymen	13
Platers and processors	2

In studying the allocation of the engineering man-hour costs, it is necessary first to understand the procedure followed by the engineering department in the design of a new plane. This falls into three divisions: preliminary design, project engineering, and flight testing. Generally speaking, preliminary design comprises approximately 5 to 10 percent of the total engineering hours applied to a production airplane. This includes all time accumulated in the precontract stage. The percentage mentioned is based on the assumption that no experimental airplane is built, and that the research design group works to a general Air Corps specification. Often manufacturers build an experimental airplane "on speculation"; this procedure obviously changes the entire research and design picture.

Under Standard Air Corps practice, a bid specification is sent to manufacturers concerned, stating within definite limits the type and performance requirements. From this point, the steps in preliminary design are traced.

Preliminary Design

1. Preliminary design group studies the Air Corps specification and prepares a digest of salient requirements.

2. A preliminary determination is made of the weight, wing area, and arrangement of general features.

3. On the basis of the preliminary determination, a revised weight check is made and the balance investigated.

4. A preliminary performance check is made, using several alternate engines as a basis for calculation.

5. An inboard profile drawing and a standard three-view drawing are prepared, subject to revision. From this stage onward, several variations of design may be carried through each operation and incorporated in the final bid data. Therefore the time accumulation in the remaining steps will be directly proportional to the number of alternates established, and to the extent in which they differ from the basic design. It is not unusual for as many as 75 alternates to be submitted with a bid on a given type.

6. Individual studies are made to determine the preliminary design of landing gear, power plant installation, armament and cockpit arrangement.

7. Revised weight and balance calculations are prepared incorporating the results of all research to this point.

8. A company specification and artist's sketch of the proposed type are prepared. In some instances a preliminary mock-up of the type is constructed.

9. A check is made on the structural design and preliminary layouts of wings and fuselage are prepared.

10. Final inboard profile and a corrected three-view drawing are made.

11. Required proposal drawings are made, usually including the following components and installations: armament, power plant, wing, fuselage, landing gear, empennage, communicating equipment, pyrotechnics and miscellaneous installations.

Normally the work of the preliminary design group ends at this point, and all data and drawings are assembled and submitted with the firm's bid.

DOUGLAS AIRCRAFT COMPANY bases the following costs on actual development and construction of four representative airplanes averaged down and made applicable to an airplane of 25,000 lb. or a medium-sized bomber. Overhead is included.

	DOLLARS	PERCENT
Engine and loft	251,000	26.9
Tooling	53,700	5.8
Shop Labor	404,000	43.2
Material—raw	86,600	9.3
Government furnished	48,500	5.2
Flight test	31,900	3.4
Wind tunnel	14,300	1.5
Miscellaneous	4,000	0.4
Administrative	40,000	4.3
Total	439,000	100.0

Project Engineering

Assuming that the bid is accepted and an order is placed, all data are immediately turned over to the project engineer, who proceeds somewhat as follows:

1. Study of changes in preliminary design requested by Air Corps.

2. Construction of a wind-tunnel scale model if wind-tunnel tests are desired.

3. Construction of a final mock-up for Air Corps approval.

4. Prepare final approved drawings.

5. Assignment of various components to design groups by the project engineer. The work of these groups is directed and coordinated by the project engineer. Permanent groups under independent direction handle power plant design, electrical and instrument design and hydraulics design, but the project engineer coordinates these special phases, and also directs the groups established for detail design of wings, fuselage, empennage, surface controls.

6. Detail design of parts and assemblies by the various design groups.

7. Construction of power plant test stand and execution of engine tests for approval of installation and cooling arrangements.

8. Structural tests on test specimens.

9. Construction of a static test airplane simultaneous with the construction of the prototype airplane.

10. Final weighing and inspection of all components.

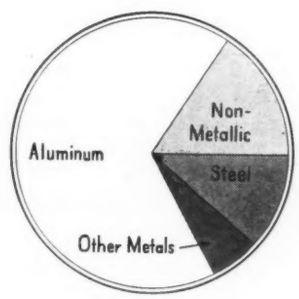
11. Flight testing.

12. Minor changes to facilitate production.

Although the outline above roughly covers the work of the project group, it does not tell the whole story of concentrated engineering research which must be coordinated before the first airplane goes up for flight tests. Several other independent groups work concurrently with the project group.

One of these groups is the weights group, which maintains a continuous weight and balance check during actual assembly of the prototype airplane. As parts and assemblies are designed, they are investigated by the stress group, which also conducts physical tests on specimens whenever necessary. All detail drawings are examined by the checking department. Still another part of the coordinated engineering task is accomplished by the research laboratory, where chemists and metallurgical engineers work constantly in an effort to improve materials and production processes.

When the prototype airplane is finally in the air—which may be weeks or may be months from the date the bid became a contract, depending upon the type of airplane and upon a thousand other factors—there begins a series of flight tests which are pretty certain to reveal any miscalculations which might have passed the preliminary design group, the project group, and the various other research and checking groups. Because no science is omniscient, an airplane has rarely if ever been designed to perfection before taking the ultimate test of all science—physical demonstration.



MATERIALS DOLLAR

Materials that go into the training plane studied

MATERIALS	PERCENT
Sheets	32
Bars	20
Extrusions	6
Tubing	5
Castings	9
Forgings	6
Fabric	1
Plastics	3
Rubber	3
Wire and Cable	5
Miscellaneous	10
	100

Flight Tests

Manufacturer's flight tests on a U. S. Army Air Corps Advanced Training type usually begin with cooling tests at maximum power and cruising power in level flight and climb.

Next, performance is tested, using maximum power in level flight to determine high speed, and using maximum power in climb to determine the time required to climb to a given altitude, the service ceiling, and the maximum rate of climb. At cruising power in level flight, the pilot records cruising speed, from which endurance and range are calculated. Landing speed is checked by actual landings with full flaps, and a motion picture is taken from which aerodynamicists quickly compute the distance required to land after passing over an obstacle 50 ft. high, and the distance required to take off over a 50 ft. obstacle.

Maneuver tests on a training type usually consist of a power dive to 6 G's, right and left five-turn spins, and stalls —as well as other military maneuvers. From this series of maneuver tests, the experienced pilot is often able to suggest minor design changes which will improve handling characteristics. Any structural weaknesses will inevitably be revealed in the tests, which subject the ship to strains far higher than any that will be encountered in normal military service.

Engineering Time

The total engineering time spent in the design of the airplane includes time spent in drafting, clerical, stress, checking, weights, tracing, aerodynamics and project engineering. In this typical case, drafting man-hours comprised approximately 52 percent of the total engineering man-hours. A breakdown of total engineering time by percentages follows:

Drafting	52
Clerical	23
Stress analysis	6
Checking	7
Weights	3
Tracing	4
Aerodynamics	2
Project engineers	3

It is apparent from these percentages that comparatively little research was necessary, as demonstrated by the low percentage shown for aerodynamics. The type under consideration was a training airplane which followed, in general, the design of a type previously built, and therefore the picture presented would be entirely different if a totally new design were used for the comparison.

Drafting man-hours can in turn be broken down into the time spent on engineering the component parts of the airplane. Percentage figures are:

General airplane	7.9
Wing	19.0
Empennage	5.1
Fuselage	14.7
Landing gear	1.5
Power plant	21.7
Fixed equipment	3.1
Electrical	8.3
Radio	4.7
Armament	0.3
Instruments	3.6
Surface controls	3.4
Hydraulics	6.7

These figures are for a relatively simple type of training plane. The engineering time required to design the more complicated types of fighting planes must necessarily be much greater. Using as a base the total engineering time required to design a two-place advanced training monoplane of the type built by North American Aviation for the U. S. Army Air Corps, it can be estimated that twice as many hours would be required for a single-engine fighter, that four times as many hours would go into the design of a twin-engine bomber, and that eight times as many hours might be required for the design of a four-engine stratesphere bomber. But such estimates can be only guesswork unless all details of a definite specification are known and studied.

CASTINGS AND FORGINGS

ERNEST GEIGER

IN DESIGNING for castings, forgings and stampings, the many simple little details that make shop operations easier and cheaper should be carefully checked for correctness. Rights and wrongs of many of these details are illustrated on these pages. Although all changes suggested in the sketches are simple ones—in many cases involving merely the change of a contour—they may result in large savings in time, materials and tools. Similar articles covering the small details in designing for machining and assembly will appear in later numbers of PRODUCT ENGINEERING.

CASTINGS

WRONG

RIGHT

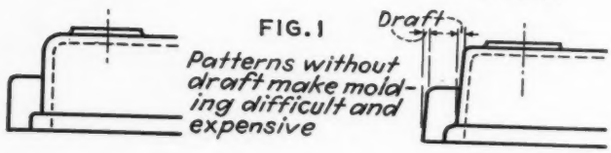


FIG. 1
Patterns without draft make molding difficult and expensive

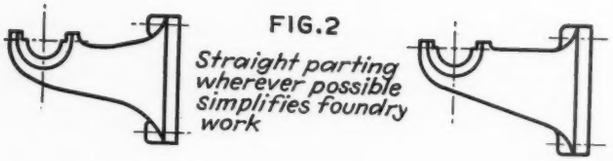


FIG. 2
Straight parting wherever possible simplifies foundry work

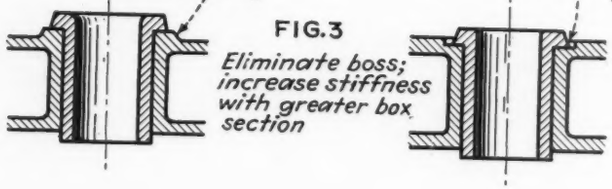


FIG. 3
Eliminate boss; increase stiffness with greater box section

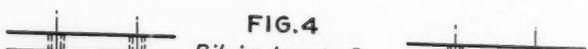


FIG. 4
Rib instead of bosses; permits shifting hole location

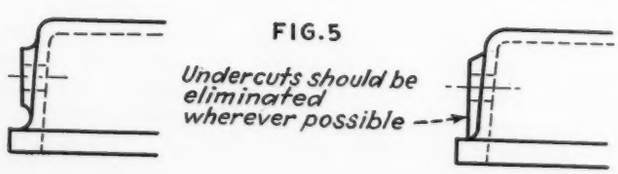


FIG. 5
Undercuts should be eliminated wherever possible

CASTINGS

WRONG

RIGHT

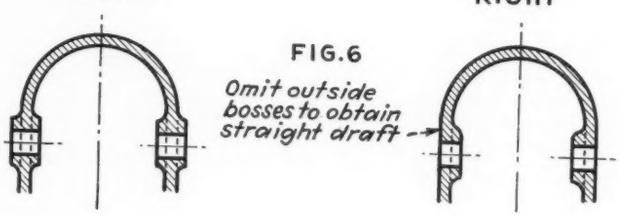


FIG. 6
Omit outside bosses to obtain straight draft

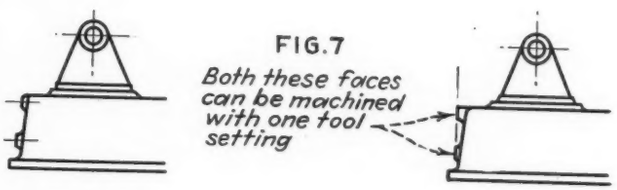


FIG. 7
Both these faces can be machined with one tool setting

FIG. 8
Panel of uniform thickness instead of many pads of varying height simplifies machining

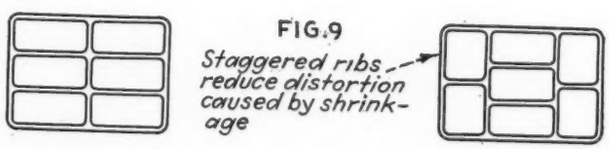


FIG. 9
Staggered ribs reduce distortion caused by shrinkage

FIG. 10
Redesign saves weight, material and machining costs

The Rights and Wrongs of Details

CASTINGS

WRONG RIGHT

FIG. 11

Core extension prevents shifting during pouring, permits design with thinner wall

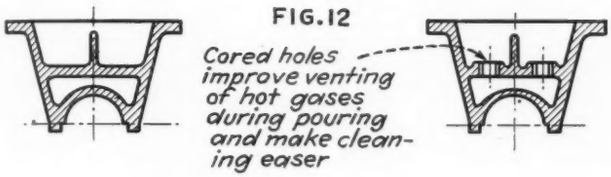


FIG. 12

Cored holes improve venting of hot gases during pouring and make cleaning easer

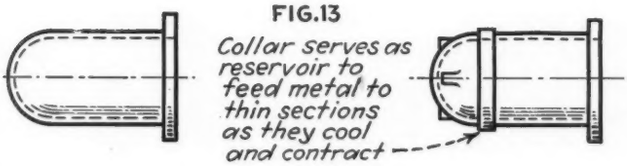


FIG. 13

Collar serves as reservoir to feed metal to thin sections as they cool and contract

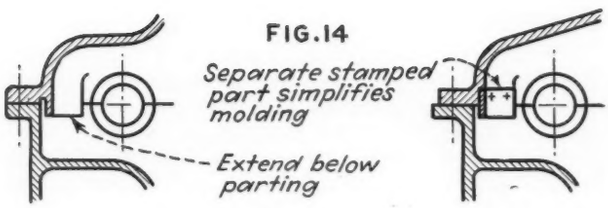


FIG. 14

Separate stamped part simplifies molding

Extend below parting

FORGINGS

WRONG RIGHT

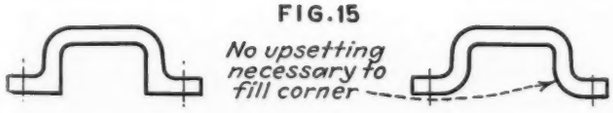


FIG. 15

No upsetting necessary to fill corner

FORGINGS

WRONG RIGHT

FIG. 16

Curved side difficult to forge

Straight sides, lower cost

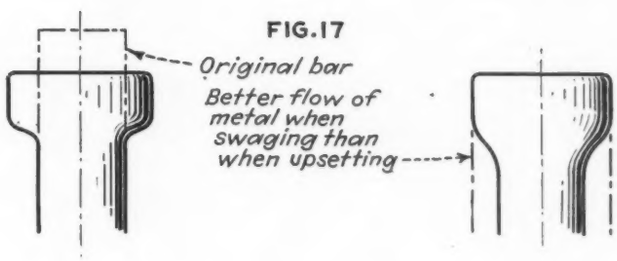


FIG. 17

Original bar

Better flow of metal when swaging than when upsetting

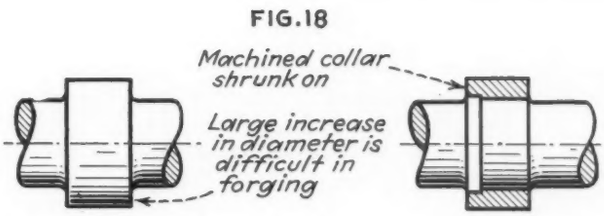


FIG. 18

Machined collar shrunk on

Large increase in diameter is difficult in forging

FIG. 19

Difficult forging and machining eliminated by two-piece assembly

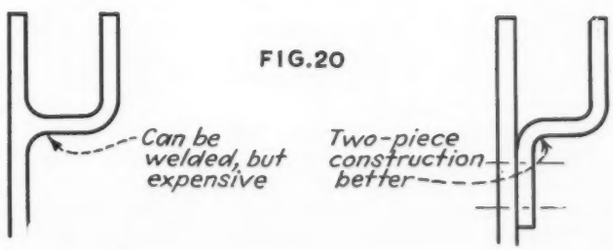


FIG. 20

Can be welded, but expensive

Two-piece construction better

FATIGUE TEST RESULTS

Their Use in Design Calculations

E. C. HARTMANN
Research Laboratories, Aluminum Company of America

THE DESIGN of almost all strength members is based primarily on a consideration of static loads. Even if impact loadings are encountered, they are reduced to equivalent static loads for purposes of design. When a member is to be subjected to many cycles of repeated load in service, however, there is no easy method of reducing the design problem to one of simple static loading and the engineer, if he does not ignore the repeated loadings entirely, may simply compare the endurance limit of the material with the static design stresses.

The shortcomings of the above approach to the fatigue problem in design can perhaps best be made apparent by an example. Suppose a structural engineer is designing a bridge floor member built up of silicon steel plates and shapes riveted together to form a plate girder. Calculations show that during its service the member may be subjected to one or two million cycles of high stress and therefore might well be checked from the standpoint of fatigue action. A value of one-half the tensile strength, or about 42,000 lb. per sq. in., is considered representative of the endurance limit of silicon steel. The accepted tensile design stress for the material is 24,000 lb. per sq. in. Dividing the endurance limit by the design stress, gives a factor of safety of 1.75 against failure by fatigue, which probably seems adequate.

This analysis is entirely superficial and may be misleading. The endurance limit which the engineer has used is based on tests of polished specimens free from all "stress raisers" such as holes, nicks, mill scale and the like, many of which are present in the girder and lower its resistance to fatigue. On the other hand, the endurance limit selected represents complete reversal of tension-compression stress, whereas the tension flange of the girder is probably never stressed in compression and may even have an appreciable dead load tension stress which represents the minimum stress in each cycle. Furthermore, the endurance limit is based on ten million or more cycles of stress while the girder will receive but a fraction of this number of cycles of high stress.

The foregoing example shows how

the fatigue test results can be misused by applying them to cases in design where the conditions of the test do not fit the service conditions. To guard against making such faulty fatigue analyses of design problems various factors should be given consideration. Some of these factors are:

1. Stress range under consideration.
2. Number of cycles.
3. Condition of the surface of the metal.
4. Influence of holes, notches, re-entrant corners, and other points of stress concentration.
5. Effect of plastic action at stresses above the elastic range.

Stress Range

By far the most common types of fatigue tests are those which involve complete reversal of tension-compression stresses. They are made in rotating-beam machines or reverse-bending machines and sometimes in direct tension-compression machines. The results of such tests are not directly applicable to design problems unless the stress range in the strength member under consideration is also one involving complete reversal of tensional-compression stress. Railroad car axles which rotate in the journals so that the various extreme fibers pass alternately through tension and compression, are an example of the type of problem to which fatigue data on complete reversal of flexural stress may apply directly. Many strength members, however, do not fall into this classification but are so loaded that their normal stress cycle is from zero to some maximum stress in tension or compression. Other members have an appreciable dead load stress upon which the live load stress is superimposed and the stress cycle is therefore from some low value of tension to some higher value of tension, or from some low value of compression to some higher value of compression. Occasionally a member is found in which the dead load stress is of one sign while the live load stress is of the opposite sign so that the stress range may be from some low value of compression to some high value of tension or vice versa.

In each case it is important that the fatigue data used be for a stress range reasonably close to that for which the member in question is being designed. Data on stress ranges other than complete reversal are usually obtained in some form of direct tension-compression fatigue testing machine, one type of which has been described by R. L. Templin (Ref. 1). Although such data are not readily available for all engineering materials, certain relations between the fatigue strengths for various stress ranges have been established (Ref. 2) and may be used to approximate the fatigue strengths of metals for stress ranges other than complete reversal, provided the results of tests made in complete reversal are available. For example, for many steels, the endurance limit for a stress range from zero to maximum tension is about 50 per cent higher than the endurance limit for complete reversal of tension-compression stresses. The fatigue strengths of several aluminum alloys for a number of different stress ranges have been published in Table 6 of the Structural Aluminum Handbook (Ref. 3).

Number of Cycles

The principal purpose of most fatigue investigations has been to establish an endurance limit, that is, "a limiting stress below which metal will withstand without fracture an indefinitely large number of cycles of stress" (Ref. 4). The limiting stress below which a metal will withstand without fracture any given number of cycles less than that defining the endurance limit is called the fatigue strength of the metal at the particular number of cycles under consideration. Often the fatigue strength at some relatively low number of cycles is more important than the endurance limit of the material because in many applications the number of cycles of stress encountered is considerably less than that defining the endurance limit. For most steels it has been found that the endurance limit can be established without continuing the tests much beyond ten million cycles. For most non-ferrous metals it is common practice to conduct the fatigue tests out to five hundred million cycles in order to establish their endurance limits. If all other factors are properly evaluated, it is ultra-conservative to use an endurance limit when analyzing a member which will not in service receive the large number of cycles of stress represented by the endurance limit.

Fatigue data are often plotted in the form of S-N curves in which the stresses are plotted as ordinates using a Cartesian scale and the numbers of cycles are plotted as abscissae using a logarithmic scale. When such curves are available, it is a simple matter to select the fatigue strength corresponding to any desired number of cycles. When only the endurance limit is quoted, however, it is difficult to estimate the fatigue strength at any smaller number of cycles. The fatigue strengths for several aluminum alloys are tabulated in the Structural Aluminum Handbook (Ref. 3) for numbers of cycles ranging from one hundred thousand to five hundred million.

It is often difficult to predict the number of cycles to which a given strength member is likely to be subjected in service. In general, there seems to be more of a tendency to overestimate than to under-estimate the number of cycles. One reason for this is that some of the cycles of stress to which a member may be subjected are of no importance because the stresses are relatively low. The only cycles which should be counted, ordinarily, are those at stresses equal to or closely approaching the maximum for which the member is designed. In the case of the floor members of a highway bridge, for example, the design is often based on a loaded 20-ton truck, and the number of cycles used should equal the number of loads equivalent to a loaded 20-ton truck which may pass over the member. Many millions of vehicles may pass over the member during the life of the bridge but relatively few of these, alone or in combination, will produce stresses as great as that for which the member was designed.

Condition of Surface

Most fatigue tests are made on polished specimens in which every effort is made to eliminate "stress raisers." Fatigue strengths determined using such specimens, of course, do not apply directly to strength members which do not have such a perfect surface. Scratches, nicks, mill scale, and other surface imperfections reduce the fatigue strength of the metal appreciably and some allowance for this should always be made in applying fatigue test results to actual design problems. German tests indicate that the endurance limit of mild steel is reduced about 10 per cent simply by leaving the mill scale on the surface (Ref. 5).

Points of Stress Concentration

Stress concentrations at holes, re-entrant corners and other discontinuities of section can be taken into account in design in several ways. One way is to treat them as if they reduced the fatigue strength of the material, and to try to find a reduction factor by reference to published data. This method is likely to lead to rather large errors because one is tempted to generalize too much about the effect of different types of discontinuities on fatigue strength and also overlook the fact that a reduction factor applicable

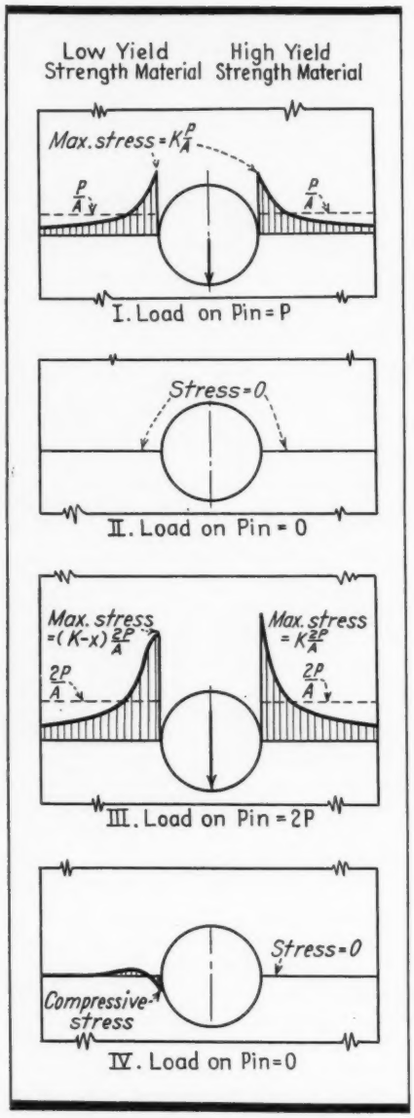


Fig. 1—Distribution of stress produced by a load on a pin in a plate

in one range of cycles may not apply in another range.

Another method of taking stress concentrations into account in design is to evaluate the magnitude of the maximum stress at the point of stress concentration and use this value rather than the nominal calculated stress in the fatigue analysis of the member. Many theoretical and empirical investigations have been made to determine the magnitudes of the maximum stresses for typical cases of stress concentration and the results are usually expressed in the form of stress concentration factors. Maximum stresses computed by the use of such stress concentration factors can, in certain limited cases, be used with suitable fatigue strength curves for the metal to determine the life of a strength member. An example of this approach to the fatigue problem is given later in this paper. Other examples are to be found in papers by R. E. Peterson and A. M. Wahl (Ref. 6 and 7).

Plastic Deformation

At points of stress concentration the maximum stresses may readily exceed the normal elastic range of the material. Stressing a ductile material beyond the yield strength, whether locally or generally, is not injurious to the static load-carrying capacity of the metal. When the plastic deformation or yielding is highly localized, as at points of stress concentrations, the yielding of the material is often highly beneficial from the standpoint of fatigue. The plastic deformation or yielding reduces the intensity of the maximum stress appreciably below what it would have been if the metal had been perfectly elastic.

In Fig. 1 is shown the stress distributions resulting from a sequence of loads applied to a tight-fitting pin or rivet in a round hole in a plate. The right-hand portion of the figure shows the conditions which exist in a high yield-strength material in which none of the stresses exceed the elastic range. The left-hand side of the figure represents the conditions which would exist for the same loadings in a lower yield strength material. In loading I the load on the pin is not sufficient to stress either material beyond its elastic range and hence the stress distribution is identical for both materials. In loading II the initial load has been released and both materials have returned to their original unstressed condition.

In loading III the load on the pin is twice as great as that applied in loading I. The stresses in the high yield strength material are all exactly twice those for loading I, but in the low yield strength material, the peak of the stress-distribution diagram has been rounded off because of plastic yielding of the material. In loading IV the load has been again reduced to zero, the high yield strength material has returned to its original unstressed condition while the low yield strength material has developed a small compressive stress adjacent to the hole, balanced by tensile stresses in the region just beyond. These residual stresses are set up because of the per-

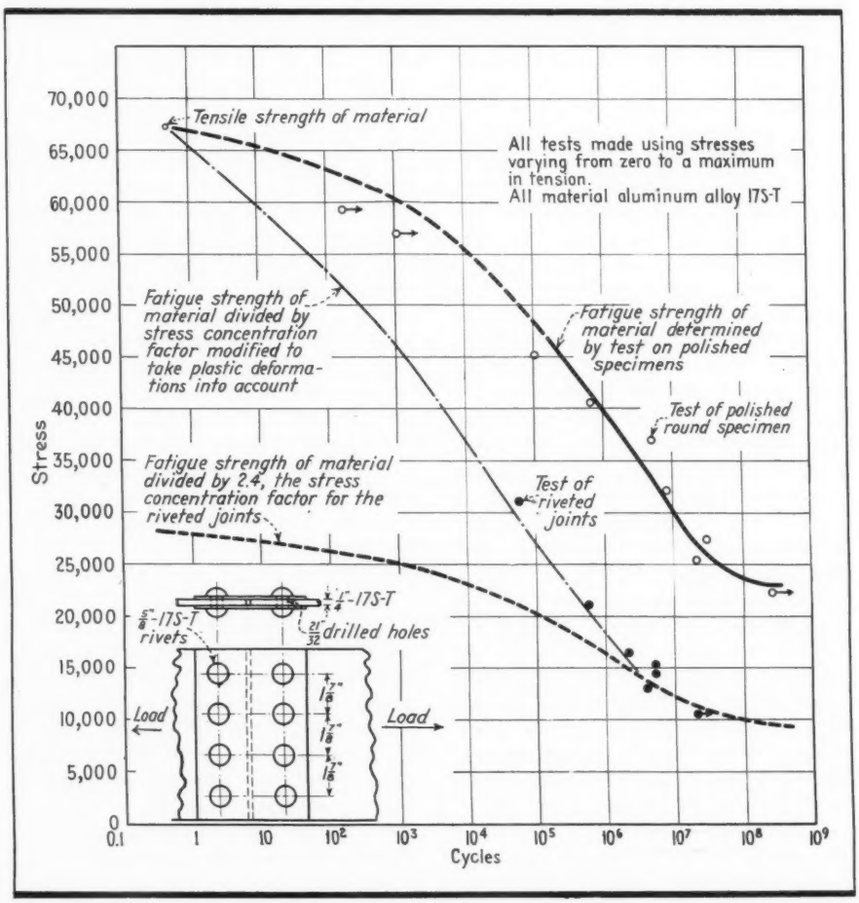


Fig. 2—Direct tension fatigue tests on polished specimens and on riveted joints

manent set which occurred in the metal during loading III. During any reapplication of loading III the stress at the edge of the hole in the low yield strength material must range from the residual compressive stress up to the reduced maximum tensile stress. The residual compressive stress at the edge of the hole is not particularly important and does not greatly detract from the beneficial effects of the reduction in the peak stress.

Plastic deformation are not cumulative with each successive application of load. A piece of metal will always take a permanent set on the first application of load which stresses it beyond its elastic range, but on succeeding applications of this same load, it will behave elastically and appreciable additional permanent set will not occur until some succeeding load exceeds the load which produced the original permanent set.

Because plastic deformation reduces stress concentrations below the theoretical values, the use of theoretical stress concentration factors is not likely to give accurate predictions of the fatigue strength of members built of the lower yield strength materials, unless some means is found to correct the factors when the maximum stresses exceed the elastic range.

In order to show how one might employ such factors in predicting the strength of an aluminum alloy riveted joint, a specific example will be given. The joint selected, detailed in Fig. 2, is one for which fatigue test results have already been published (Ref. 8).

The uppermost curve in Fig. 2 shows the fatigue strength of the plate material used in the riveted joints under consideration, determined by tests of polished round specimens. Most of the tests were made in a direct tension testing machine of the type described in the paper already mentioned (Ref. 1). The uppermost point, however, is simply the static tensile strength of the material determined by breaking a specimen in an Amsler hydraulic testing machine designed for static tests. The two test results plotted just below the tensile strength were obtained by loading specimens repeatedly in the same Amsler testing machine. These tests could not be run in the direct tension fatigue testing machine because of the excessively high loads involved. The arrows pointing to the right on these two data points and on the lowest data point, indicate that the specimens were removed from the machine before failure. This was done because enough cycles had been run to indicate the trend of the curve and because the time required to complete the test was considered prohibitive.

Knowing the fatigue strength of the material used in the riveted joint, the next step in the problem is to determine the stress concentration factor for the type of construction under consideration. This will be done by reference to the paper by Frocht and Hill, (Ref. 9), which gives the results of photoelastic determinations of stress in plates loaded through pins in round holes. Unfortunately, this paper does not cover the case of more than two pins but the assumption will be made that any number of pins can be treated the same as two pins, provided the ratio of pin diameter to plate width is evaluated on the basis advocated in the paper, namely, by using an equivalent single pin with the same "ratio of bearing to mean tensile stress." On this basis the ratio of pin diameter to plate width is 21/32 to 1⅞ or 0.35. Fig. 5 of the paper by Frocht and Hill, reproduced here as Fig. 3, shows that when the edge distance is greater than the hole diameter, when the pin is a neat fit in the hole, and when the ratio of diameter to plate width is 0.35, the stress concentration factor for a single pin is 3.0, based on the average stress on the net area. The paper also states the stress concentration factor for two symmetrically situated pins is about 20 per cent less than the corresponding value for a plate loaded through a single pin. On this basis one arrives at a stress concentration factor of 2.4 for the joint under consideration.

The predicted fatigue strengths of the joint in terms of nominal stress on the net section, may now be obtained by dividing the fatigue strengths of the material by this stress concentration factor. The lowest curve in Fig. 2 represents the fatigue strengths of the joint determined in this manner. For comparison with this predicted curve, Fig. 2 also shows the fatigue strengths of actual joints of the type in question determined in riveted joint fatigue testing machines (Ref. 8). It will be noted that the predicted curve fits the experimentally determined points at the right-hand end, but lies far below the experimentally determined points at lower numbers of cycles. The reason for the lack of agreement at the lower numbers of cycles is that in using a constant stress concentration factor, the effects of plastic deformation at stresses above the elastic range of

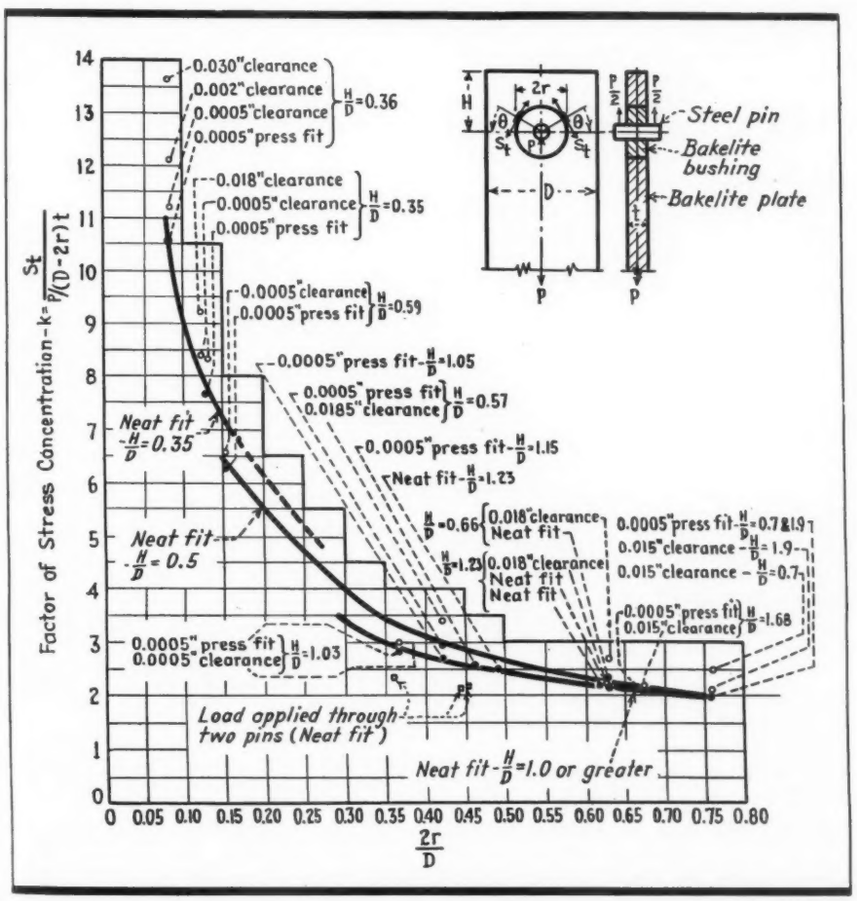


Fig. 3—Stress concentration factors determined photoelastically by Frocht and Hill

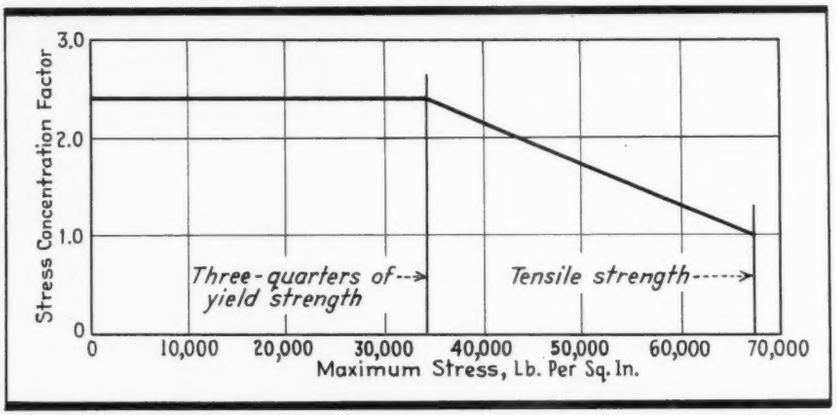


Fig. 4—Proposed method of modifying stress concentration factors to take plastic deformations into account in 17S-T aluminum alloy

the material have not been taken into account. It is difficult to predict accurately the effects of plastic deformation but an empirical method, applicable to aluminum alloys, is available.

Tests of riveted joints and other types of fatigue specimens have shown that where ductile metals are involved, the ultimate load on the specimen can be predicted fairly close by multiplying the net area by the tensile strength of the material (Ref. 8). In effect, this means that the stress concentration factor approaches unity as the maximum stress approaches the tensile strength of the material. This fact becomes the basis for the proposed empirical method of modifying stress concentration factors to take into account plastic deformation.

In Fig. 4 is shown the proposed method applied to the riveted joints under consideration in the present example. The normal stress concentration factor, 2.4, is plotted as a horizontal line for stresses from zero to three quarters of the yield strength of the material. At this point a straight line is drawn sloping downward to the right so that it passes through the point represented by a stress concentration of unity at the tensile strength of the material. A point three-quarters of the yield strength is selected rather than the yield strength because it is well known that in the aluminum alloys, as in many other metals, plastic action begins at stresses somewhat below the yield strength, and the ratio, ¾, is fairly representative of the point at which this action is likely to become noticeable in the type of behavior under consideration.

Returning to Fig. 2, the intermediate curve shows the effect of using the modified stress concentration factors taken from Fig. 4. It will be noted that this curve is in excellent agreement with the higher test results obtained on the riveted joints.

It has been shown in the example just cited that it is possible to predict the fatigue strength of a given riveted joint with a fair degree of accuracy using only the proper fatigue strength curve for the material, an approximate stress concentration factor and an empirical method for reducing the stress concentration factor to take into account plastic action. It should be realized that with the limited amount of data available today, however, it would be impossible to apply the method generally. In fact, many cases arising in ordinary design appear to be so complex that it will probably always be difficult or impossible to apply the method to all cases. For example, in simple lap joints in riveted structures, the stress concentration at the edge of a hole is different at one surface of the plate from that at the other surface, and the difference depends upon the amount of flexing permitted in the plates by whatever restraining members are present in the vicinity of the joint.

In joints with multiple rows of rivets, the stress concentration at the edge of any hole is very complex not only because of the unknown non-uniform distribution of load among the rivets, but also because the stress in the vicinity of any hole is caused partly by the load transferred by the rivet in that hole and partly by the load transferred by adjacent rivets in the next row. In welded members one has to deal not only with the stress concentrations at the edges of the welds and the method for correcting these for plastic action, but in addition, one must know something about the effect of the heat of the welding upon the fatigue strength of the base metal and on the fatigue strength of the weld metal.

Because of these uncertainties it seems almost hopeless to attempt to learn very much about the fatigue strength of members in general simply by analysis of simplified individual cases based on stress concentration factors and amplified fatigue strength curves for the various engineering materials. A more direct and generally satisfactory method of attack would seem to be by tests of representative strength members along the lines described by W. M. Wilson and R. L. Templin (Ref. 8 and 10). While no such set of experiments can hope to cover all of the varieties of strength members with which the designer must deal, yet over a period of years such investigations will result in the accumulation of data which will guide the engineer in the selection of safe working stresses for the design of various types of members. Even more important than this, the results of such tests will eventually show the difference between designs intended to resist repeated loads and designs intended to resist static loads, thereby enabling the engineer to arrive at structures which can resist fatigue action more efficiently.

(Ref. 1) "The Fatigue Properties of Light Metals and Alloys," by R. L. Templin, *Proceedings A.S.T.M.*, Vol. 33, Part II, 1933.

(Ref. 2) "The Fatigue of Metals," by Moore and Kommers, McGraw-Hill Book Co., 1927.

(Ref. 3) "Structural Aluminum Handbook," by the Aluminum Company of America, 1938 and 1940.

(Ref. 4) Report of Research Committee on Fatigue of Metals, *Proceedings A.S.T.M.*, Vol. 30, Part I, 1930.

(Ref. 5) "Korrosion und Dauerfestigkeit," by A. Thum and H. Ochs, *VDI-Verlag GMBH*, 1937.

(Ref. 6) "Stress Concentration Phenomena in Fatigue of Metals," by R. E. Peterson, *Transactions A.S.M.E.*, Applied Mechanics, Oct.-Dec. 1933.

(Ref. 7) "Two and Three-Dimensional Cases of Stress Concentration and Comparison with Fatigue Tests," by R. E. Peterson and A. M. Wahl, A.S.M.E. *Journal of Applied Mechanics*, Mar. 1936.

(Ref. 8) "Fatigue Machines for Testing Structural Units," by R. L. Templin, *Proceedings A.S.T.M.*, Vol. 39, 1939.

(Ref. 9) "Stress Concentration Factors Around a Central Circular Hole in a Plate Loaded Through a Pin in the Hole," by M. M. Frocht and H. N. Hill, A.S.M.E. *Journal of Applied Mechanics*, Mar. 1940.

(Ref. 10) "Fatigue Tests of Riveted Joints," by Wilbur M. Wilson and Frank P. Thomas, University of Illinois Engineering Experiment Station Bulletin No. 302.

"Tension Tests of Large Riveted Joints," by Davis, Woodruff and Davis, *A.S.C.E. Proceedings*, May 1939.

See also discussion by Hartmann and Holt of "Tension Tests of Large Riveted Joints," *A.S.C.E. Proceedings*, May 1940.

HYDRAULIC COUPLINGS—II

Application Characteristics of Variable-Speed Types

R. D. McCAUSLAND

Hydraulic Coupling Division, American Blower Corporation

WHEN the quantity of oil within the working circuit of a hydraulic coupling is varied, the amount of energy transmitted to the runner varies accordingly; thus stepless speed control can be obtained. Variable-speed hydraulic couplings operate on the same principles of energy transmission as the traction type, using identical parts: impeller, runner and inner casing, but in addition include a manifold, scoop tube, outer casing and oil reservoir, so that oil can be added or removed from the working circuit of the coupling while the unit is operating.

Two general types of variable-speed hydraulic couplings are in use. The older type, mainly for heavy-duty applications, is pump-controlled and is known as the VS type, Fig. 8. Inactive oil is stored in a stationary tank. With the working circuit of the hydraulic coupling emptied of oil, the prime mover can be started while completely disconnected from the load. When the motor-driven gear pump, automatically or remote-manually controlled, pumps oil from the reservoir tank through the manifold into the working circuit of the coupling, the amount of energy transmitted to the runner increases, and the driven shaft speeds up. When the working circuit is completely filled, the driven shaft operates at a speed approximately 2 percent less than that of the driving shaft, and operating characteristics approximate those of the traction-type coupling described in the first part of this article, which appeared in the January number of PRODUCT ENGINEERING.

Oil is continually thrown from the working circuit through calibrated leak-off nozzles, and, by the force of impingement against the open scoop tube, circulates through an oil cooler and back into the working circuit. To reduce output shaft speed, oil is drawn from the coupling by the pump and stored in reservoir. Thus infinitely variable speed is available at the driven shaft.

A more recently developed variable-speed unit is the scoop-control hydraulic coupling, Fig. 9. As the name implies, the speed of this coupling is varied by changing the angular position of a movable scoop tube. Instead of the stationary reservoir tank and motor-driven pump, as in the VS type, the outer casing acts as a rotating reservoir for storing inactive oil. When the unit is stationary, all the oil lies in the lower half of the casing below the level of the driven shaft. Thus oil seals are unnecessary. When the prime mover is started, the casing rotates with it. The oil is held by centrifugal force in a rim or belt around the outer part of the casing, away from the working circuit. With only air in the working circuit, the driving unit can thus be brought up to speed without

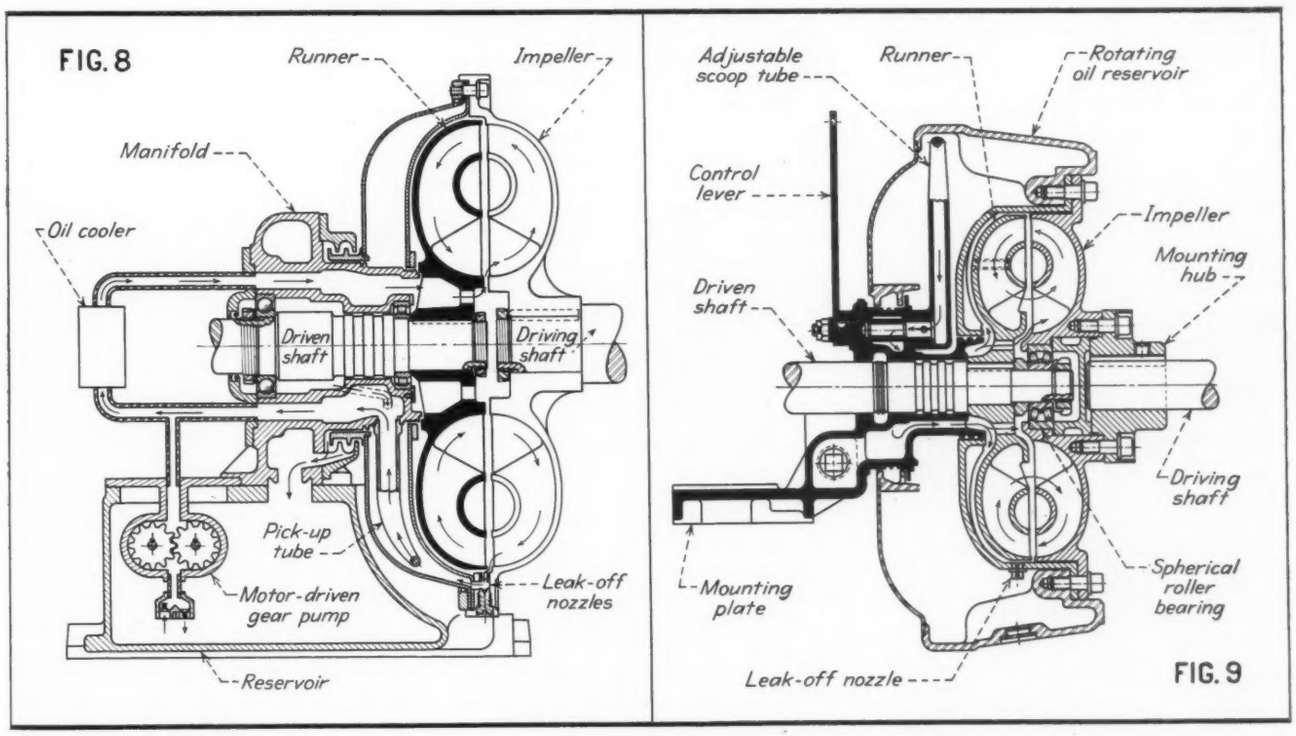


Fig. 8—Pump-controlled, variable-speed hydraulic coupling having separate reservoir, pump and remote-control valves to vary amount of oil in working circuit. Fig. 9—Scoop-control, variable-speed hydraulic coupling, a self-contained unit in which the outer casing acts as a rotating reservoir. When unit is stationary, all oil lies below level of driven shaft

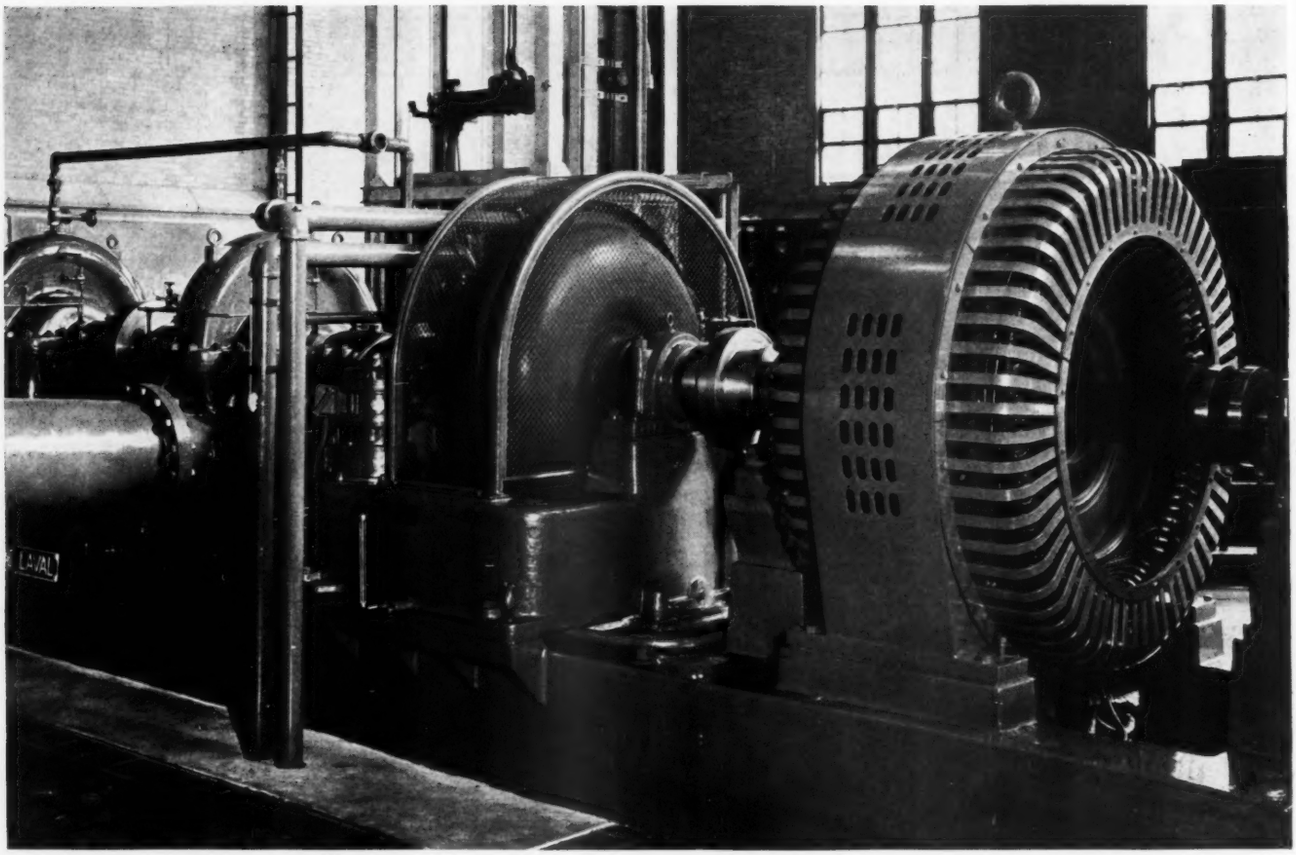


Fig. 10—Synchronous motor driving pumps through a pump-controlled, variable-speed coupling, installed in Knoxville Water Works

engagement of the load being driven.

The scoop tube is controlled by an external lever arm and is pivoted on an eccentric in such a manner that it can be moved into the rotating belt of oil. Thus a certain definite quantity of oil will be tapped off from the rotating reservoir depending upon how far the scoop tube is moved into the oil, leaving the remainder inactive in the casing. The oil that is tapped off is forced through the tube by impingement against the open end of the scoop and is thrown directly through the manifold into the working circuit of the coupling. As in the pump-controlled coupling, leak-off nozzles continually drain oil from the working circuit into the reservoir casing where it is again picked up by the scoop tube and the cycle repeated.

The scoop tube can be set at any intermediate position between "full-in" and "full-out," hence the quantity of oil in the working circuit, which governs the speed of the output shaft, can be governed to give "split-revolution control" over a speed ranging from 20 percent to 98 percent of the driving shaft speed. It may be necessary to hold this speed range to closer limits in some constant-torque applications. Since this control method is relatively simple and only involves the movement of a lever arm through an arc of about 90 deg., it readily lends itself to either automatic or manual control.

Pump-controlled hydraulic couplings in drives such as large mechanical draft fans and turbo-blowers allow the use of constant-speed motors. Savings in power are possible, as compared with volume control by dampening or throttling. A wider range of control is available than with motors of the wound-rotor, slip-ring type. The adaptability of the hydraulic coupling to automatic control makes it feasible for driving forced and induced draft fans which maintain constant pressure or constant volume under varying demand conditions. Erosion of blades is reduced by dropping the speed of the fans rather than allowing them to run at a constant speed and controlling capacity by means of dampers.

The scoop-controlled hydraulic coupling, accomplishing the same results as the pump-type coupling, is limited to relatively light duties. Although it has been used extensively on oil drilling rigs in Europe, it has only been in the last few years that it has been installed on rigs made in the United States. In such applications, in addition to preventing engine stalling on overload, the coupling maintains pressure on a stalled slush pump, provides variable speed for coring and fishing operations, and engages and disengages the engine.

For variable speed and smooth starting the scoop-control coupling can be utilized to advantage on winding machines and coating machines. Automatic control can be applied to maintain a constant speed as close as plus or minus one percent.

A variable-speed hydraulic coupling in a paper mill installation provides smooth transmission of torque without mechanical connection between driving and driven members, and also provides "stepless" variable-speed control and is readily adaptable to automatic control. Since the main drive of a paper machine requires close speed regulation to secure a uniform grade of paper, many machines use sectional drives with d.c. motors to regulate the draw between sections. On earlier installations, a single d.c. motor drove the entire machine through a countershaft from which the individual drives were taken by belts running on cone pulleys. Recent installations have an a.c. motor, and a variable-speed hydraulic coupling driving the countershaft. Load fluctuations are automatically compensated by adding and removing oil from the hydraulic coupling through valves.

COLOR PSYCHOLOGY

Its Place in Product Design

DON LEE HADLEY
Design Consultant, Westinghouse Electric & Mfg. Company

LINE, form and color are the basic elements that determine the appearance of a product. They are the three elements with which the industrial designer must work to achieve a pleasing result. But they are closely related and only by their proper use and combination can effective results be achieved. It is obvious that line and form are interdependent and interlocked. But although it may not be so apparent to the layman, the color scheme with which the product is dressed will largely determine the visual impression which the product makes. Certain colors emphasize, others subdue; some colors make surfaces appear larger; others make them look smaller; some colors harmonize, others clash.

Every problem in industrial design begins with the selection of the type or character of the form most suitable for the particular product under consideration. The modern keynote is simplicity, which calls for the elimination of extraneous projections and surface adornment. Simple geometric figures such as are found in nature are made the basis of the form. Circles, spheres, squares, cubes, rectangles, cylinders, triangles and cones are used with variations and combinations. Which to use will be dictated largely by the shape and dimensions demanded by engineering design requirements. But by the judicious use of variants and combinations, the expert designer is able to blend or hide otherwise grotesque features required of the engineering design.

A typical example of a relatively simple application of industrial design principles is a recently redesigned portable arc welder. Before redesign, this device was a simple rectangular box measuring about 28x22x19 in. The box, which housed all the mechanical and electrical parts, was mounted on two large spoked wheels and a large caster in front. A piece of ¾ in. diameter steel rod served as a handle. The color scheme was dark gray body and black wheels. As can be seen in the illustration, all corners were sharp, which, together with the spoked wheels, gave the product a harsh appearance.

The first step in the redesign of the welder was to make rough perspective outline sketches to establish the general overall form of the proposed redesign. In this case, the rectangle and circle were the obvious predominating geometric forms that must be used. To retain simplicity and minimize the number of different geometric shapes used, the wheels were shown as simple circles, that is, the spokes were eliminated by using disk wheels.

Having decided that the general over-all dimensions and proportions were satisfactory, the next thing was to see what could be done to soften the contours of the box. Approximately a 1-in. radius could be formed at the vertical corners, but this immediately seemed to entail a necessity for a stamped or drawn cover to conform to these radii. The handle also was redesigned to give a more finished appearance. Introduction of a deeper stamped cover naturally involved expensive dies and tools. A little investigation showed that another manufacturing department of the company was already using such a cover on an entirely different type of apparatus. This cover so closely approximated the dimensions chosen for the welder that by making only slight changes in the body the existing cover could be made with no additional tool investment. It was therefore adopted. New wheels of the disk type were substituted; they have three ridges em-

(a) Before designer went to work, welder looked like this—merely a box, mounted on spoked wheels. The handle appeared as if it had been an afterthought

(b) First step in redesign was to round sharp corners, make the handle form a part of the design

(c) Changing to disk wheels simplified the lines. Parallel lines on top of the pressed cover added a decorative note and broke the monotony of the flat surface

(d) This is the final result. Nothing revolutionary has been done, but a few rounded contours and the addition of proper color certainly added sales appeal

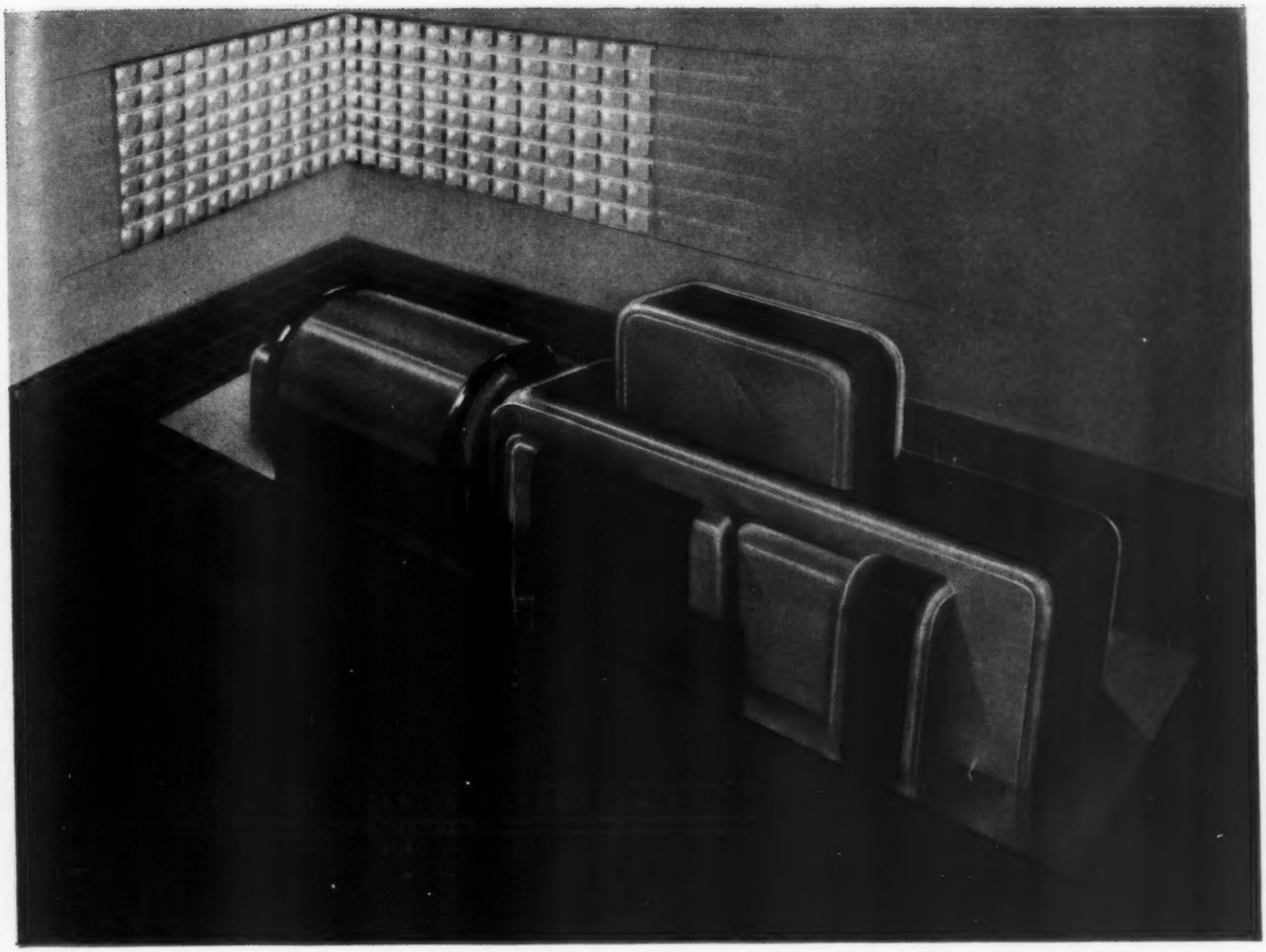
In designing a big machine, such as a turbine generator, the architecture of the surroundings must be taken into consideration. This is about what a typical modern machine looks like. From the designer's point of view its composite shape is too confusing; it has too many conflicting lines. Color is "machine-tool" gray, and it is not in harmony with surrounding colors

bossed in them for added strength, and incidentally add a pleasing simplicity to the design.

Apparatus such as a welder, which is to be used in garages, machine shops, and similar shops is frequently finished in any sort of color or surface, just so it is durable, because it will rapidly become dirty and disfigured. Any time or money spent in trying to dress it up is usually considered wasted. Nevertheless, since first impressions count heavily in selling, a note of color was added deliberately in this design to attract attention. Several colors were considered before settling on a dark stippled green for the body, with baked-on aluminum finish for the cover and wheels and a chrome-plated tubular handle.

In considering design as applied to household merchandise, it becomes apparent that the past few years have seen a general leveling off of basic fundamental forms with a general trend toward simplicity of design. Although household devices are still adorned with a great deal of chrome-plated trim, this is primarily a concession to popular demand. Most designers probably would like to dispense with as much of it as possible. The designer is often asked why ranges and refrigerators are not produced in an assortment of colors. Anyone who will take the trouble to go into some research will find that these devices have been offered to the public in a wide range of colors. During the early history of range design they were finished mostly in black, which was a natural hangover from the days of coal and wood-burning stoves. With the development of porcelain enamel it became possible to introduce color, and both gas and electric ranges were offered in ivory, yellow, green, blue, gray, and possibly a few others. One by one the colors disappeared with the exception of ivory, which for a period of two or three years held the field alone. After running the cycle of colors, new finishes such as imitation marble and imitation wood graining began to be introduced. Fortunately, most of these monstrosities enjoyed a brief existence. About 1930 ranges finished in all white porcelain enamel began to make their appearance and after two or three years gained a predominant position in the field. White ranges are still the most popular and their popularity will likely continue for an indefinite period because to the housewife white symbolizes cleanliness. Other devices such as refrigerators, washing machines and water heaters also went through the same process. Today, with few exceptions, practically all manufacturers have standardized on white. Any added color is used to a limited degree, usually on handles, hinges, nameplates, control knobs, or accessories such as baking dishes and pottery normally used with refrigerators.

In industrial apparatus there is at present not much demand for color, but rather for a great variety of finishes



A turbine-generator may look like this some day. Architecture of both machine and building have been simplified; the predominant color is light, bluish gray. Most of the color planes are parallel to the major axis, which accentuates the "slimness" of the machine. The floor covering is of a contrasting hue, to make the machine stand out boldly

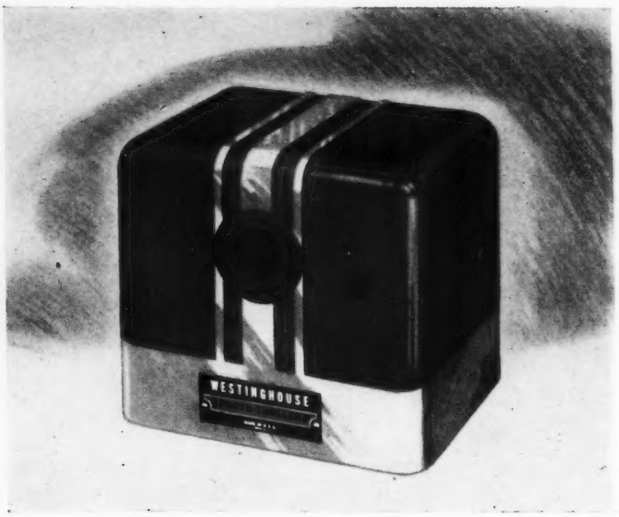
involving all types of paints, lacquers and varnishes and all types of surface finishes, ranging from a coarse splatter finish to an extremely high gloss. With the exception of fractional-horsepower motors, practically all rotating electrical equipment is finished in what is called a machine-tool gray. This finish was adopted by the manufacturers of machine-tool equipment a few years ago and is generally adhered to by most manufacturers of large industrial equipment. While the machine-tool gray makes an acceptable finish for outdoor apparatus, it is too dark and gloomy on large indoor apparatus, except under the most favorable lighting conditions. However, it has been so universally accepted that it will be difficult to sell the idea of a substitute, especially in color.

The principal objection to the present machine-tool gray finish is that every manufacturer seems to have his own opinions as to what constitutes machine-tool gray. In large organizations several departments may use this finish, and there may be as many as four or five variations of the same theme. This, to a certain extent, can be traced to the fact that when a manufacturer requests from some paint supplier a sample of machine-tool gray, and turns it over to his laboratory staff, they will match the sample closely. This paint may then be applied to a piece of apparatus as large as a turbo-generator, while in another department it may be applied to a small portable tool. Owing to disproportions of the two areas and their different contours, the same paint may look entirely different on the two machines. Actual samples of machine-tool gray range anywhere from a warm gray with a brownish cast to a deep gray with the predominance of blue. If manufacturers wish to be consistent and adopt a standard finish regardless of its hue, they will have to control this problem in their laboratories.

In the design of control apparatus the designer is confronted with a similar condition. He can use any finish, as long as it is black. Of course, there is a logical reason for the use of dull, satin black on control boards and panels. It has a low light reflection value, which is about 2 percent. However, a rich deep blue with a reflection value of only 9 percent—certainly not enough to cause any trouble in reading the meters and instruments which are mounted on the panels—could be used.

High-gloss finish is objectionable on many industrial products in spite of the fact that it is used on certain types of machinery. It is undesirable for two reasons: (1) it is hard on the eyes of the operator; (2) it has a tendency to show up flaws and defects in the material. This is especially true where heavy sheets of fabricated steel or iron are used. A high-gloss finish on sand castings shows up every flaw and pit. Even though the castings may have been filed and sanded the high gloss still reflects certain unevenness in the sur-

Properly designed for line and form, this plastic cabinet is fairly good-looking, but lacks something



This is it. Color makes the whole thing stand out; contrasting metallic lines tie the base and top together

faces. By using a soft or semi-gloss finish similar to lacquer, the effect would be far more pleasing to the eye.

Occasionally industrial consumers express dissatisfaction with the so-called standard finishes and request that their machines be shipped finished with only a priming coat to prevent rust in transit. These users have their own particular likes in color.

It is only in recent years that manufacturers have begun to be appearance conscious with respect to industrial apparatus, and today many designers are devoting a large portion of their time to this activity. As the three-dimensional forms of these devices undergo a face lifting, there is an increasing need for paying closer attention to surface finishes. The attractiveness of a properly designed piece of apparatus can be entirely nullified by the use of improper colors and finishes.

By virtue of their function, certain types of machines and devices do not render themselves to good proportional design, and it is at this point that the designer depends upon surface conditions to accent the strong points of the design and subordinate the weak points by the introduction of another color or finish. Probably industrial apparatus never should be finished in pink or fire-engine red. But manufacturers should realize that color will greatly enhance the eye appeal of their products. There is no logical reason why dark, drab grays and blacks must always be used.

Color, if properly handled and applied, can immeasurably enhance the appearance of any device or any piece of apparatus regardless of its nature. What is needed today more than anything else is to persuade the manufacturer that color psychology has played and can play an important part in sales and customer satisfaction. But the desired results can be achieved with assurance only when the color scheme is developed by one who has the necessary experience and artistic ability to qualify as an expert on color selection and application.

Some Axioms of Industrial Design

Color

Depth of color changes size. Light colors make an object seem to be bigger. Dark colors will decrease the apparent size of an object.

Colors change shape. Lines or planes in colors contrasting either in hue or value with the main color are accentuated. Warm colors—reds, oranges, purples—appear to make planes and lines "advance". Cool colors—blues, greens, yellows—make them "recede".

Colors have psychological effect. Generally women like warm colors; men prefer cool ones. Bright, warm colors in large masses are hard to look at for long periods. They are exciting, and may actually contribute to accelerated body reactions in sensitive people. Cool colors are restful, passive. Light colors suggest cleanliness or gaiety; dark ones are depressing.

Gradual transitions in color. As in form, sudden transitions are not normally pleasing. Components in color contrasting vividly with that of the main mass may be over-accentuated. Continuity of form can be achieved by a gradual blend of one color into the other, or by using related colors.

Line and Form

Simplicity the keynote. The eye likes a simply shaped object that can be comprehended without much effort.

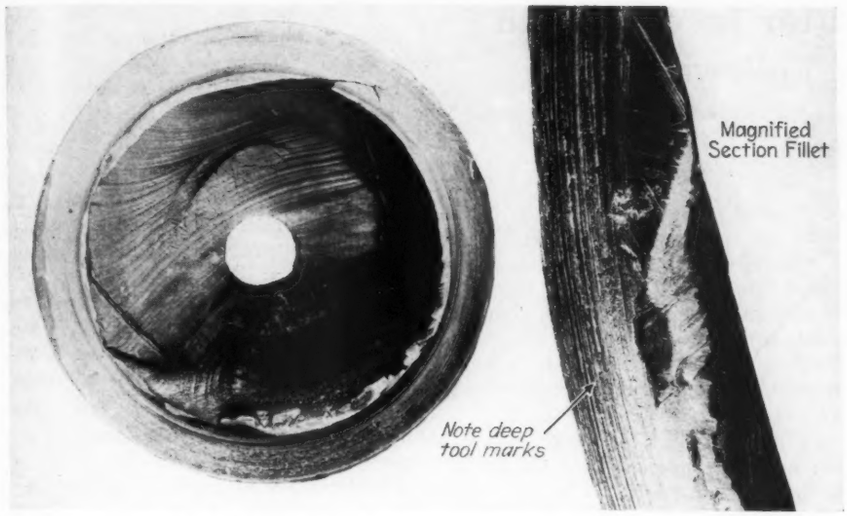
Lines should be congruous. Auxiliary lines should agree with the dominant shape of the object. Straight lines may be radial or tangential against a circular background, but should be arranged symmetrically. If the dominant shape is straight-sided, auxiliary straight lines should be parallel or have some other obvious relation.

Gradual transitions in shape. Additions to the main shape should agree with it, and should not be abrupt in transition. This is the essence of "streamlining".

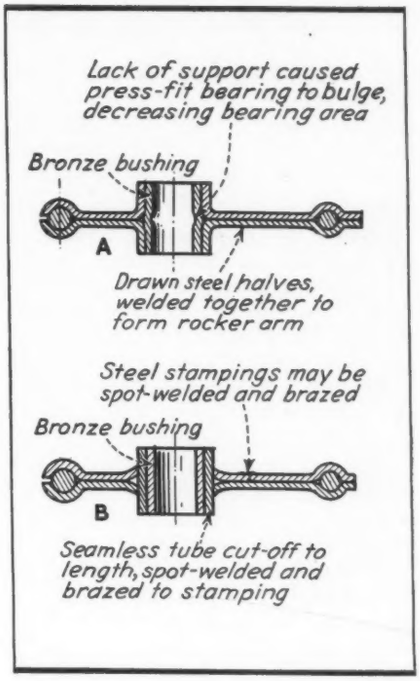
Best proportions. The rule that the short side of a rectangle should be about 62 per cent of the long side, won't always work, but it is a starting point.

The eye can be fooled. A high, narrow form may look dignified or stately, but may be weak. Broad, low objects look strong, especially if they are wider at the base. A solid appearing mass looks stronger than the same object made up of many smaller elements. Lines parallel to an axis of an object exaggerate the dimension of the object along that axis.

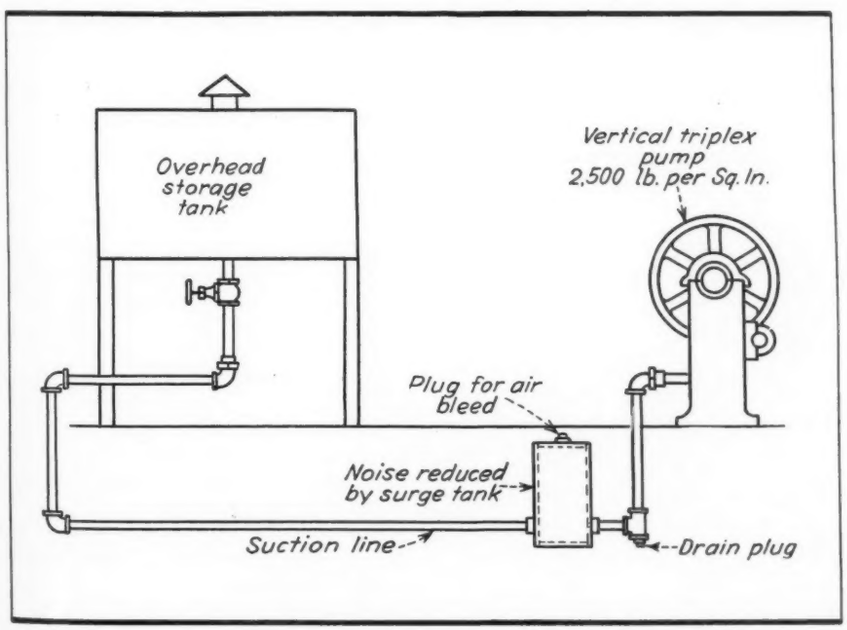
Causes and Cures



Deep tool marks in the fillet of this locomotive crankpin caused fatigue fracture. As shown in the magnified portion at right, the tool tore into the surface and left deep grooves. Cracks started in these grooves, resulting in a typical fatigue failure. Many such failures have been reported in locomotive parts—failures which could be prevented by specifying smoother finish.


Lack of support caused press-fit bearing to bulge, decreasing bearing area
Bronze bushing
A
Drawn steel halves, welded together to form rocker arm
Steel stampings may be spot-welded and brazed
Bronze bushing
B
Seamless tube cut-off to length, spot-welded and brazed to stamping

Fabricated rocker arm for diesel engine when redesigned from cast part as in *A*, developed trouble when it was discovered that the bronze bushing bulged out into the joint space between the deep-drawn bosses of the steel halves. Effective bearing area was reduced, causing early failure. Solution, shown in *B*, is to fabricate the rocker arm from two stampings and a short piece of seamless tube. Stampings and the seamless tube are assembled and held in a simple jig and welded or brazed.



High-pressure vertical triplex pump was extremely noisy under load, although quiet enough when pumping at low pressure. Cause was finally traced to water hammer in the suction line, caused by bends and length, despite the 12 ft. static head. The noise was cured by inserting an air chamber in the suction line at the pump as shown. This chamber consists of a vertical 3-ft. length of 14-in. pipe with flat ends welded in. Pipe plugs were fitted at the top and bottom to adjust the air content.

HARDENED ROLLERS, although they have longer wearing life under ordinary conditions, will often crack under heavy impact loads or shock. Such failures in hardened rollers of all sizes have been reported, from rollers 2 ft. in diameter used in heavy machinery down to small rollers used under the drawers of office filing cabinets. Since it would be necessary in such cases to greatly increase the size of hardened steel rollers to prevent cracking under impact loads, the best solution has been found to be the use of soft steel rollers.

PRODUCT ENGINEERING will pay $3 for each example published in Causes and Cures. Where illustrations are necessary, include drawings, rough sketches or photographs.

Question and Comment

Mathematical Solution for Involute Cam Problems of Radial Follower Type

BERNHARD F. PAGEL
Detroit, Michigan

Involute cam problems of the radial follower type can readily be solved by a simple mathematical process. Necessary dimensions for constructing the involute curve can be calculated directly from the given data. Textbook methods are semi-graphical in procedure and necessitate a preliminary construction of a standard involute curve from which graphical data are proportionally translated to fit the requirements of the specific problem. Obviously, this process is both lengthy and inaccurate. This mathematical method, however, permits the designer to proceed directly to the task of laying out the cam with the assurance that calculated values will produce required results.

All involute cam layouts of this type involve three factors: maximum pressure angle, working angle, and the distance the radial follower moves. These factors are incorporated in the cam layout and a particular involute curve is constructed which will satisfy these given requirements. The problem then is reduced to the task of finding the radius of the basic circle of the required involute curve and finding the shortest radius of the pitch circle of the cam. The required curve can readily be constructed and the layout completed in the usual manner.

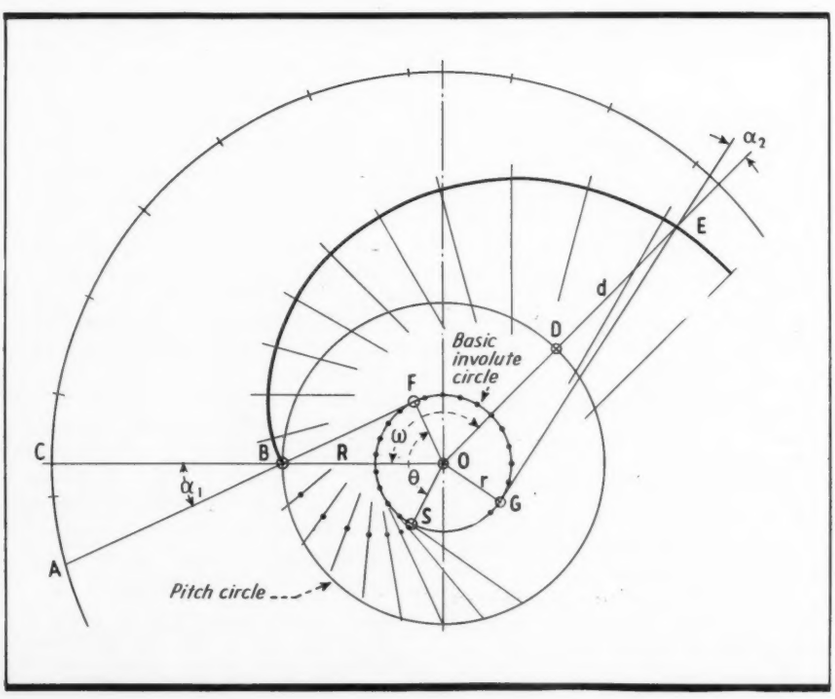
To find a formula for the basic involute circle we proceed as follows: In the figure below, angle ABC is the given maximum pressure angle denoted by α_1; angle COE is the given working angle of the cam noted by ω; and the line segment DE denoted by d is the distance the radial follower moves. If r represents the radius of the basic involute circle, then in right triangle BOF

$$BO = r \csc \alpha_1$$

Similarly, in the right triangle EOG

$$OE = r \csc \alpha_2$$

where α_2 is the pressure angle at the end of the working angle ω.



Subtracting the first equation from the second and substituting d the radial follower distance for (OE − BO) the formula for the basic involute circle becomes

$$r = \frac{d}{\csc \alpha_2 - \csc \alpha_1}$$

The formula for the shortest radius of the pitch circle R follows directly, for in the right triangle BOF

$$R = BO = r \csc \alpha_1$$

To solve problems we need merely to evaluate csc α_1 and csc α_2. Since α_1 is one of the given factors we find csc α_1 directly from tables or from its equivalent form $\csc \alpha_1 = \sqrt{1 + \cot^2 \alpha_1}$. The value of csc α_2, however, is not found as directly and we must proceed to evaluate it in the following manner. In the figure it is easily demonstrated that

$$\cot \alpha_2 = \alpha_1 + \theta + \omega - \alpha_2$$

in which the angles to the right of the equality sign are in radian measure, and θ is the angle SOF from the origin of the involute to the side OF. From this equation we get:

$$\alpha_2 + \cot \alpha_2 = \alpha_1 + \theta + \omega$$
$$= \alpha_1 + \cot \alpha_1 + \omega \text{ (radians)}$$

The value of θ is found from the fact that $\theta = \cot \alpha_1$. As all the values to the right of the equality sign are given numerical quantities, we proceed to find the nearest value to $(\alpha_2 + \cot \alpha_2)$ in trigonometric tables and hence arrive at the value of cot α_2. Substituting, we get

$$\csc \alpha_2 = \sqrt{1 + \cot^2 \alpha_2}$$

Four or five place tables with intervals of 10 min. of arc are accurate enough in most cases in determining the nearest value of $(\alpha_2 + \cot \alpha_2)$.

Sample Problem

Find the radius of the basic involute circle and also the shortest radius of the pitch circle for an involute (radial follower type) cam in which the maximum pressure angle $\alpha_1 = 25$ deg., $\omega = 135$ deg. and radial follower movement $d = 3$ units.

Solution:

$$\csc \alpha_1 = \csc 25^\circ = \sqrt{1 + \cot^2 25^\circ}$$
$$= 2.36620$$

Since

$$\alpha_2 + \cot \alpha_2 = \alpha_1 + \cot \alpha_1 + \omega$$

the values become

$$\alpha_1 = 25^\circ = 0.43633 \text{ radians}$$
$$\cot \alpha_1 = \cot 25^\circ = 2.14451$$
$$\omega = 135^\circ = 2.35619 \text{ radians}$$

Substituting, we find

$$\alpha_2 + \cot \alpha_2 = 4.93703$$

By adding the radian value of an angle to its cotangent value and comparing the sum to the above value, we find the nearest value for cot α_2 to be

$$\cot \alpha_2 = 4.73170 \text{ approx.}$$

and therefore

$$\csc \alpha_2 = \sqrt{1 + \cot^2 \alpha_2} = 4.83621$$

Substituting these values of csc α_1 and csc α_2 in the formula developed above, we have

$$r = \frac{d}{\csc \alpha_2 - \csc \alpha_1} = \frac{3.00}{4.83621 - 2.36620} = 1.21 \text{ units.}$$

Also, the shortest radius of the pitch circle

$$R = r\csc\alpha_1 = 1.21 \csc 25^\circ = 2.86 \text{ units.}$$

A great deal of time and labor can be saved in solving problems of the above type by making use of a prepared table similar to the one below. This would be of an advantage to those who find it necessary to solve many problems. The table given here is abbreviated to include only those numbers which apply directly to the problem solved above.

Using this table to solve the above problem, we would have:

$$\csc 25^\circ = 2.36620$$

Also, since

$\alpha_2 + \cot\alpha_2 = \alpha_1 + \cot\alpha_1 + \omega = 4.93703$ is closest to the value of 4.93998 in the table, therefore

$$\csc \alpha_2 = 4.83621$$

For more accurate results, interpolation may be employed. These values of csc α_1 and csc α_2 can now be directly substituted in the formula for the radius of the basic involute circle developed above.

Angle α, (Radians)	Angle α (Degrees)	$\alpha + \cot \alpha$	$\csc \alpha$
0.43633	25° 00′	2.58084	2.36620
0.20799	11° 55′	4.94650	4.84288
0.20828	11° 56′	4.93998	4.83621
0.20857	11° 57′	4.93347	4.82956

What Practice is Right In Placing Dimensions?

To the Editor:

The great interest in aeroplane manufacture in this territory discloses a very annoying right-about-face in what has been considered correct in vertical dimensions. The American Standards Association booklet entitled *Drawing and Drafting Room Practice* states as follows: "All dimension lines and their corresponding numbers should be placed so that they may be read from the bottom or right-hand edge of the drawing." This has been commonly understood for years although there have been complaints about the placing of the figures on the vertical dimensions.

When I tell my students in engineering drawing that there exists a great difference in technique and conventions in the various plants throughout the country, I point out that most of the authorities endeavor to agree on the basic fundamentals. What am I to do when after stressing one thing from one authority, some individual confronts me with a direct contradiction?

Baughman's *Aviation Dictionary and Reference Guide* states: "All dimensions should be placed to read from the lower edge of the drawings."

I am heartily in accord with this latter recommendation dealing with this particular phase of drawing. I think the idea is based on sound common sense. The drawing is not only easier to read but there is greater facility in placing the figures. —John Homewood

Ontario, Cal.

Everybody's All Wet On Water Lily Problem

To the Editor:

I have just stumbled across your "How Deep the Pond?" problem, which was put up to your readers in the September 1940 number of Product Engineering. I also read Mr. Loveless' letter in the December number, calling attention to the fact that the original problem was misworded, and that the correct answer should be 17 ft.

Truth of the matter is that everybody's all wet! Water lilies do not grow in ponds 17 ft. deep. —R. J. Lobe

Lansdowne, Pa.

[*Editor's Note*—We don't know much about water lilies so we called up our Consulting Editor on Botany and Related Subjects to check on Mr. Lobe's statement. Sure enough, water lilies (nymphaeaceous plants, genus *castalia odorata*) grow only in shallow ponds. In case you want to engineer a lily pond for your back yard, we suggest you take the advice of Mr. R. Pinkus, water lily expert of the New York Botanical Garden, who states he gets best results with ponds about 3 ft. deep, practically no results in ponds over 5 feet deep.]

Kink for Saving Time in Drawing Similar Designs

To the Editor:

It is possible to save at least 25 percent of the designing cost when a number of pressed parts of common shape and contour but with different overall dimensions are required. For instance, where six different sizes of pressed refrigerator caps are required, namely for 3, 4, 5, 6, 7 and 9 cu.ft. refrigerators, usual practice has been to make one design and tabulate the dimensions which differ, or to make six different designs. The tabulated drawing has considerably increased the hazard of mistakes being made by the designer or the builder of the tool. Making a separate tracing for each of the different caps is expensive and also causes undesirable delays in completing the drawings. The following is a description of a method to overcome the difficulties of both of the above procedures.

On tracing paper or cloth draw the design, for example, for one size refrigerator cap showing all of the dimensions common to all sizes, and omitting all of the dimensions which differ among the several sizes. Then make six positive prints on translucent paper from the original tracing. Next fill in on the prints all of the previously omitted dimensions and necessary information to complete the design, using one print for each size cap. From each, which now has a complete design, make blueprints. File the translucent copy for future reference.

This method simplifies designing, prevents possible mistakes that happen when using tabulated blueprints, provides the die room with enough prints for distribution to die makers and machine hands, and also saves on designing time and cost.

Dies for pressed metal may be divided into several groups, such as forming, draw, trim, blank, pierce, progressive, compound. The same may be said about fixtures and jigs. They also may be divided into groups, such as drilling, milling, welding. Therefore, if a number of translucent prints are made for each group and kept in stock, they may be used in a manner similar to that described above with considerable reduction in design time.

When using a pencil in the making of the original on tracing paper or cloth, care must be taken to make lines

fairly wide and black, because when reproducing the lines have a tendency to become faint to a certain extent. Therefore, if a great many copies are to be made from a single original, it is practical to use drawing ink when making the original.

Through the above described methods, we have been able to standardize our designs, to have designs finished on short notice and reduce cost of designing considerably.

—VICTOR S. VOIGHT
Westinghouse Electric & Mfg. Co., Mansfield, Ohio

Suggests Pendulum Device As Flywheel Substitute

To the Editor:

A substitute for a flywheel was requested by Samuel Wesert, page 325 of PRODUCT ENGINEERING for July 1940. Mr. Wesert stated he wanted to use it to dampen out torsional vibrations in a turntable.

There is on the market a recently developed device which under certain conditions can substitute a flywheel. This device can give exactly the same dynamical effect as a flywheel many times heavier than the device itself, and belongs to the class of dynamic vibration suppressors.

In its simplest form, this device consists of a free pendulum suspended from the part of the machine from which a periodical disturbance of uniform rotation is to be eliminated. The action is most efficient when the pendulum is tuned with the frequency of the disturbing force. Under these conditions the effect of the pendulum may be considered as an increase in inertia (flywheel effect) of the part of the machine mentioned, and can be expressed by formulas.

It might be of interest to note that the pendulum system was developed by Bernhard Solomon, R. Sarazin, E. S. Taylor and R. Chilton, almost simultaneously. The patent situation therefore is quite intricate since it is difficult to determine definitely the exact priority of each of them.

It seems, however, that Mr. Solomon's claims have the best foundation. This invention and especially the latest developments of Mr. Solomon present possibilities of building extremely efficient devices for elimination of torsional as also translatory ocillations.

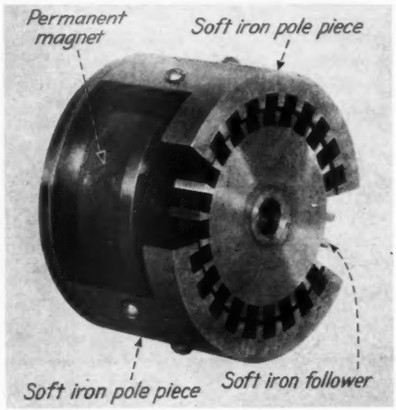
It may be considered the last word in torsional vibration elimination, and is being successfully applied to internal combustion engines.

—LEON M. DEKANSKI
New York, N. Y.

Permanent Magnet in Magnetic Coupling

To the Editor:

Your article "Permanent Magnets in Mechanical Applications," published in the January number, has brought to mind a typical application of a permanent magnet in a magnetic coupling. This coupling, designed about three years ago, is for applications different from any shown in your article, so would probably be of interest to your readers.



Details of the design of the magnet and pole-pieces are illustrated in the photograph. The cast Alnico magnet is held rigidly in place when the coupling assembly is screwed together.

—H. BACHRACH
Schenectady, N. Y.

Total Load on Bolt Open for Discussion

To the Editor:

J. J. Pesqueira's article "Location of Jam Nuts" must necessarily take into consideration the stretching of the bolt and nut and the transfer of load and points of pressure which result from this elasticity. This leads us into another important controversial subject:

Should the total load on a bolt be considered as the initial load, the applied load, or the sum of the two?

Ask many a design engineer this question and he is apt to say, "It depends," and let it go at that. "It depends," of course, but upon what? Undoubtedly some of your readers have done considerable thinking about this problem, and I for one would like to see a discussion of it in this column.

—R. D. THOMSEN
Milwaukee, Wis.

Can You Work This One?

H. E. SMITH

This month's problem—

XXX Division

In this problem, which has as many unknowns as an automobile frame design problem, each X denotes a digit. You're given enough numbers to reconstruct the entire example.

```
          XXX
XXX ) XXXXXX
      X0XX
      ----
      XXXX
      X50X
      ----
       XXX
       X4X
       ---
       000
```

Solution to January Problem—

Brain Testers

1. If Joe is now 28 years old, and is twice as old as Jim was, then Jim was 14. But when Jim was 14, Joe was as old as Jim is now. This condition can only be satisfied by an age halfway between 14 and 28. Jim is 21 years old.

2. A motor weighing 15 lb. consists of rotor, frame, stator and bearings. Combined weight of rotor and frame is twice the weight of frame and stator. Since the weight of bearings is least of all, no fractions, the stator must weigh 2 lb. Rotor weighs 8 lb., frame weighs 4 lb., and bearings weigh 1 lb.

3. A man 5 ft. 5 in. tall is digging a hole and plans to go twice as deep as he is now, when the top of his head will be twice as far below the surface as it now is above the surface. Letting x equal original depth,

$$2x - 65 = 2(65 - x)$$

Solving this, the depth of the hole, $2x = 97\frac{1}{2}$ in., or 8 ft. $1\frac{1}{2}$ in.

4. The ten digits, when arranged to form numbers which will add to exactly 100, must be in fractional form, such as $21 - 3/6 + 78 - 45/90$. The digits 0—9 add to 45, and adding these digits will give 9; therefore the sum of any whole numbers made with these digits will be a number whose digits add to 9.

News and Summaries

Leading Automobile Manufacturers Continue With Plans For 1942 Models

National Defense expected not to curtail production immediately; Willys head urges moratorium on new models; Auto Shows cancelled

ALTHOUGH THE AUTOMOBILE INDUSTRY recognizes that the first order of business in America today is national defense, and do not claim "business as usual" in their plants, most of the leading automotive manufacturers are continuing with designs for their 1942 models. Recent reports from Detroit indicate that in few cases so far have regular work been subordinated to defense orders.

Principle causes for apprehension seem to be the possible shortage of sheet steel and alloy steels, and the present shortage of skilled labor. Strangely enough, there seems to be no shortage of skilled die-makers in the Detroit area. Many companies, including Packard, Plymouth and Ford, are putting the finishing touches to their new models and are getting ready to order dies for 1942. Changes are being kept to a minimum, and will probably involve only sheet metal. The motor manufacturers are treading lightly, but they evidently plan to be prepared in case they get the "go" signal from the government on new models.

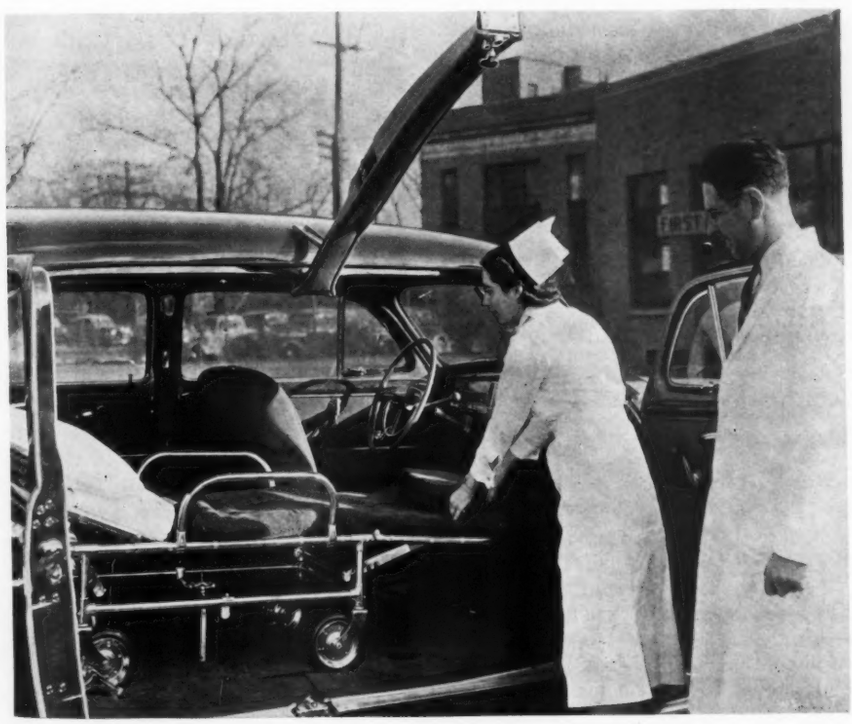
Most companies are now doing varying amounts of production on aircraft and aircraft engine parts, and on trucks and cars for the War Department, but these contracts are being taken care of in addition to regular automobile production. In some instances this has called for major changes in company organization. For example, Buick has shifted top key men to aircraft production. The assistants are left to produce the cars; the chief engineer retains supervision over both divisions.

Viewing the National Defense program and the effect it may have on near-future automobile production, Paul D. Hoffman, president of the Studebaker Corporation, stated recently:

"As to the results of the past year's activity and the prospects of the coming months, the automobile industry has reason to be both grateful and hopeful. Factory sales for the industry approximate 4,400,000 units, an increase of 23 percent over the 3,577,292 cars and trucks sold in 1939. In 1940 the industry enjoyed the largest sales since 1937, the year's volume being equal to 82 percent of the 1929 peak.

"Even in normal times, it is difficult to analyze future prospects with any degree of accuracy. Seldom before in our history has it been more difficult to do this than at present. The conditions under which industry will function during the coming year will be extraordinarily susceptible to developments beyond the control of business. International and domestic political policies will exercise a powerful influence during the months that are ahead. Assuming that disturbances from these quarters are not seriously disruptive to the domestic economy, the automobile industry in 1941 would appear to have a potential of passenger car and truck sales 10 to 15 percent greater than in 1940. In consideration of its vast importance to the welfare of the nation, the automobile industry should be encouraged to realize on its potential provided always that its activities at no time and in no way interfere with the rapid advancement of the defense program."

Reflecting this feeling of uncertainty, Joseph W. Frazer, president of Willys-Overland Motors, Inc., last month strongly urged that "all national automobile shows be eliminated entirely during the period of our national emergency and that 1941 models carry into 1942," in a telegram to Alvan Macauley, president of the Automobile Manufac-



Ambulance conversion car, a new De Soto introduction, in normal use is a 7-passenger car. By removing the right front and folding seats and lifting up the center post and hooking it to an inconspicuous roof bracket by a stainless steel arm, the car can be converted without tools into a serviceable ambulance in a few moments. Overall length is 19 ft.; wheel base is 139½ in.; engine is 110 hp. Fluid Drive and Simplimatic Transmission are optional.

turers Association. Official notice of the cancellation of the New York Automobile Show of 1941 came a short time later from the Automobile Manufacturers Association. This relieves the manufacturers of the responsibility of promoting new models, and permits the industry to devote all its energy and experience to national defense. The action will not prevent dealer's associations from sponsoring shows throughout the country, but it is expected that the weight of public sentiment may cause many privately sponsored shows to follow the lead of the manufacturers.

Engineers Needed Most By Aircraft Industry

ALTHOUGH THE FULL FORCE of the defense program has not yet been felt by industries in the New York region, a shortage of engineering personnel was revealed as an acute bottleneck in the aircraft industry by a survey of 174 manufacturing plants of 18 groups of industries, conducted in the New York industrial area by the New York Committee on Engineering Training for National Defense. In the aircraft industry, the lack of technically trained men is already so critical that unless emergency measures are taken to meet the situation, an "appalling" shortage will exist as demands of the defense program increase.

The area contains about 28,000 industrial plants employing slightly less than 850,000 wage-earners. The plants surveyed by the Committee's staff of investigators included food, textiles, forest products, paper, printing, chemical, petroleum, rubber, leather, clay, glass, aircraft, iron and steel, non-ferrous metals, machinery, and transportation equipment manufacturers.

The group of industries concerned with the manufacture of airplanes, engines, and other equipment have since 1937 multiplied the number of wage earners in this region at least fifty times over. The opinion was expressed that engineering colleges cannot make a mistake if they focus their attention, immediately and almost entirely at first, on the personnel needs of that one group of industries which within a year may be more than three times as great as at present.

Taking a cross section of 21 companies, employing 38,300 men in the New York area, it was estimated that as many as 6,000 new men will be needed within a year to fill positions for which graduate engineers would be employed in normal times. Possibly two or three times that number of technicians, including sub-professional grades, will be needed. To meet these figures, nine colleges of the city's area graduate only 1,200 engineers of all kinds each year, while the total for the nation is only 12,000.

As for other industries, the brief and preliminary survey shows that industries outside the aircraft companies need at least 1,500 technicians of all grades. There is an insistent demand for draftsmen. If the aircraft industries are assumed to require one-half the men to be trained under the defense training program, possibly three-eighths of this half will be trained draftsmen. Next to the demand for draftsmen in the aircraft industry and elsewhere, and ultimately likely to be more acute, is the demand for production men of all kinds. Here again trained engineers are preferred.

Nylon Film and Wool Developed by Du Pont

NYLON PHOTO FILM has recently been patented by the Du Pont Company. Advantages claimed over cellulose acetate and nitrate film are better flexibility, strength, durability; resistance to temperature and weather changes. In the case of movie reel, the Nylon film was projected 760 times before it broke, as compared with 300 times for nitrate and 100 for cellulose. This film is synthesized from coal, air and water, just as the yarn is, except that the film is extruded through a slit instead of pinpoint openings. Because of its strength, nylon film can be made half as thick as conventional types.

Nylon wool is also patented by Du Pont. The fiber is simply cut into staples—lengths similar to natural wool. It is then compressed into bales and heated, which puts a crinkle into each fiber. It is the crinkle in natural wool that keeps cloth springy and prevents it from felting or packing down. Felted cloth conducts heat away from the body.

Accurate Chronoscope Measures Short Intervals

PRECISELY HOW LONG it takes a fuse to blow out, a photo flash bulb to light up, a telephone relay to snap, or a blasting cap to go off, is indicated to the operator by the maximum swing of an indicating needle across a scale in a new device called a chronoscope, recently developed by the Research Division of the Remington Arms Company. The device, built into a small portable cabinet, will measure from one up to 200 milliseconds with less than 1 percent error. It has already proved valuable in Remington laboratories for studying the effect of velocity and flight time of bullets on accuracy, range, trajectory, and hitting power, but its use is not confined to ballistics.

Projectile velocities can be measured accurately over distances as short as 5 or 10 ft. "Remaining velocity" can be measured after the projectile has travelled some distance. The actual velocity at 100 or 500 yd., for instance, can be measured over 10 ft. This has been impossible with the Boulenge chronograph, the standard device in all ballistic studies for measuring short time intervals. Such measurement has been very cumbersome by any other method.

The chronoscope indicates the time interval from a quantity of electricity which passes through a specially designed galvanometer while the measured event is taking place. The galvanometer resembles a conventional portable indicating electric meter. A vacuum tube switching circuit starts the current at the beginning of the interval and stops it at the end. The photoelectric cell can be used to obtain the start and stop impulses.

In ballistic studies, the conventional muzzle wire and target plate can be used. The single scale from which readings are taken really serves as five scales. Selection is made with a switch which converts the scale to any one of five time ranges, varying from 10 to 200 milliseconds.

Remington technologists regard the instrument as a marked advance over the Boulenge chronograph, which has satisfactory accuracy on intervals of the order of 100 milliseconds, but errs excessively on those of the order of 10 milliseconds.

Do You Know That—

FRONT AXLES for automobiles which are four times more resistant to road shocks than conventional I-beam axles can be made from hot rolled tubes. (40)

COIN VENDING MACHINES were first used in early Egyptian temples. As described by Hero, they dispensed ceremonial water when the correct weight of coins was placed in a slot. (41)

PEACH FUZZ, long an annoyance to the peach-eating public, can now be removed by a new fruit grader which scrubs the peaches with rotary brushes. (42)

20,000-KVA. CONDENSER at the Gorge Steam Plant on Ohio Edison is ventilated with electrostatically cleaned air. Between 50 and 75 bushels of dirt annually will thus be kept from being blown through the windings. (43)

ENGINEERING IN WASHINGTON

McGRAW-HILL WASHINGTON BUREAU, *PAUL WOOTON, CHIEF*

One thing is certain, in a maze of contradiction that is covered by a blanket of military secrecy: aerial warfare will continue to be a contest in design; there will be no frozen models; superiority will be concentrated in performance, not in numbers of airplanes. This principle has been firmly stated, in the presence of this writer, during the last few days, by Sir Hugh Dowding, chief of Britain's home air defense; by Col. John Jouett, boss of the Aeronautical Chamber of Commerce; by Glenn L. Martin; by Guy Vaughn of Curtiss-Wright—and others.

Reduced head resistance of radial air-cooled aircraft engines was one of the important aeronautical advances of 1940. Installation and cowling, with fins giving more rapid heat dissipation, has been refined until the drag of air-cooled power plants is no greater than that of a liquid-cooled line engine of the same output. Increased cooling efficiency has contributed much to units of 2,000 hp. and over. Engineers may ask why so much time and money are being spent on liquid-cooled engines if air-cooled engines are now just as "streamlined." A big radial engine streamlines into a fat fuselage just as well as a slim engine does. Any size of airplane, up to about 300 m.p.h., can be plump without much loss in speed-power proportion. But if you want something that will really go places, a slender design is necessary. Therefore, work continues on in-line liquid-cooled engines for small, high-speed fighter planes. Incidentally, Navy now has a small shipboard fighter (the Vought-Sikorsky inverted gullwing) powered with an air-cooled engine, generally admitted to be the fastest plane in this country. The controversy has been going on for 15 years, with no end in sight. It should be added that Navy does not use liquid-cooled engines; Europe uses practically nothing else but.

Aerial cannon and ammunition are being worked on by the Army and by Britain. The term "cannon" for air means a shell-projecting piece, and a "gun" is a slug projector. Army is developing a shell of such sensitivity that it will detonate upon entering a precipitation of rain, so the story goes. It is an unconfirmed belief that cannon as large as 75 mm. are being developed for mounting on the new 70 and 80 ton bombers being built by Douglas and Martin. Reports reach Washington that hits by 37 mm. shells being used in Europe practically demolish the aircraft. But such hits are difficult and will be until cannon are developed that can fire faster than they do now. The British are showing keen interest in even more than eight machine guns per plane.

How long will it last? Plenty of technical men could decide instantly whether or not to go into Army or Navy, take up a course of study, leave one job for another, quit school, get married, divorced—if they knew how long this defense rampage will last. Nobody can tell, not even Dorothy Thompson, but here are some yardsticks with which you can make your own guestimate: If the British lose, either by a knockout or negotiation, the U. S. will arm and expand forces for years. Hitler would try to lull us with a cooperation lullaby, but we probably wouldn't go for it. If the British win, even with the help of the United States, it might take two to five years.

To keep up with the science of international destruction, the Army is expanding its Engineer Corps and rewriting its training technique. Whereas only about 70 officers have been accepted annually for training at the Engineers School, Fort Belvoir, Va., new plans call for training of 1,700 officers and 1,500 enlisted men during fiscal 1942. Already, short courses are being given to 200 reserve and regular Army officers each month. Refresher instruction is being given to Reserve and National Guard officers.

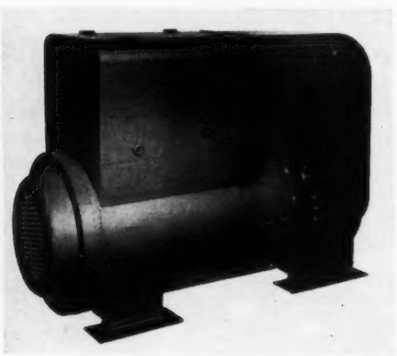
Harris & Ewing

Aiming at its adoption by Army parachute troops, Harrington & Richardson Company developed this 6½-lb., .45-cal. submachine gun, shown here firing tracers in recently publicized tests. Known as the Reising gun, it can be set for either semi-automatic or full automatic fire, shoots at rate of 500 per min., but clips hold only 20 or 50 cartridges. Barrel is fitted with heat dissipation rings and a compensator for "muzzle rise." Army has looked over the gun, which can be made for $50, but gives no definite answer as yet. If adopted, it will probably be bored for the new Army .30SM-1 cartridge, which has greater range and higher velocity than the .45's.

New Materials and Parts

Variable Speed Units

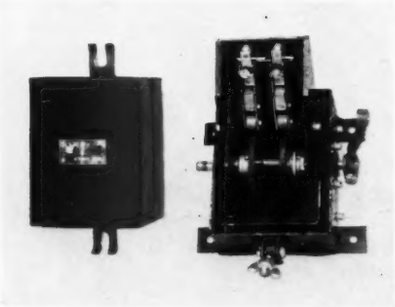
Three additional V*S units of 20, 25 and 30 hp. have recently been introduced to meet the demand for this all-electric, a.c. adjustable-speed drive in sizes which would extend this simple method of control to larger applications. The same principle of speed control is used as in the other sizes which range from 1 hp. upward. For the sake of compactness the unit has been mounted horizontally instead of vertically and particular attention has been given to



the design of the mounting brackets which contain special longitudinal rubber shock pads to insure quiet operation of the unit. Three wires from 3-phase, 60-cycle a.c. power source, which may be 220, 440 or 550 volts, are connected to the control unit exactly as would be done with any motor and control. The units provide an almost infinite number of speed variations with an overall speed range of 16:1 for continuous 24-hour duty. Reliance Electric & Engineering Co., 1088 Ivanhoe Road, Cleveland, Ohio.

Cam Limit Switch

Designed especially for control circuits of such devices as hoists, industrial trucks, and trolley coaches, this new cam-operated lever switch features a Micarta fingerboard on which the contacts are mounted and which swings upward out of the case for easy connecting, inspection and maintenance. Operation is by means of a cam shaft on which the rollers travel. These rollers make or break contacts at any point on



the travel. Contacts are self-aligning, with a compensating type operating finger. The new XC-23 limit switch is available with ratings of 2 amp. at 600 volts d.c. and 25 amp. at 110 volts a.c. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Hydraulic Pressure Switch

Universal non-flutter, positive snap-action hydraulic pressure switch is so designed that it can be used throughout the entire range of two separate capacities with only a nominal change, and is so constructed as to be explosion, dirt, oil and moisture proof. This type of design permits removal of one size hydraulic piston and replacement of another size. Thus, the capacity of the switch can be used interchangeably over an operating range of from 200 to

1,000 lb. per sq. in., to a maximum of 900 to 3,000 lb. per sq. in. operating range. An interlock solves the problem of flutter. Adjustment of the switch to balance the hydraulic pressure at any selected point is by means of a spring loaded screw. Switch can be either normally open or normally closed and can be used to control the cycling of more than one machine or process. Practically any voltages can be handled provided 30 amp. is not exceeded. Progressive Welder Co., 3028 E. Outer Drive, Detroit, Mich.

Positive Pressure Pump

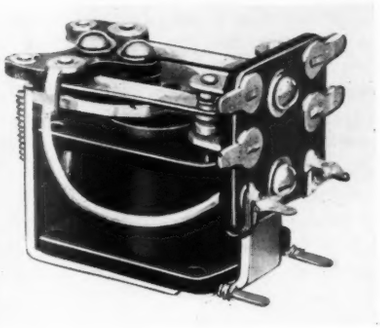
Midget positive pressure pump, known as Model UT, is designed for application in which the location of tanks and containers make the self-priming feature essential. Armature of the universal fan-cooled 1/20-hp. motor and pump impeller are mounted on a

single shaft, with adjustable stuffing box. The unit is chromium plated bronze and the motor is finished in black crackled enamel. Maximum pressure is 35 lb. per sq. in., and the maximum volume is 3 gal. per min. Eastern Engineering Co., 45 Fox St., New Haven, Conn.

Midget Relays

This new series of midget relays, which measure only $1\frac{1}{2}$x$\frac{3}{4}$x$1\frac{1}{8}$ in., feature full floating armature suspension, wiping contacts, cadmium and nickel plating of all metallic parts, high qual-

ity linen base laminated insulation. Steel coils, wound with enameled magnet wire on pure iron cores are available for operation on from 2 to 32 volts d.c. or 1.5 to 115 volts a.c. Where some degree of sensitivity is desired, positive dependable service can be attained on as little as 0.25 watts d.c. and 1 watt a.c. with a safe continuous duty rating of + 2 watts. Where intended for a.c. excitation, all relays in this series are



equipped with a specially designed pole which, together with its pure copper shading ring, provides absolutely noiseless operation free from all hum and vibration. Advance Electric Co., 1260 W. 2nd St., Los Angeles, Calif.

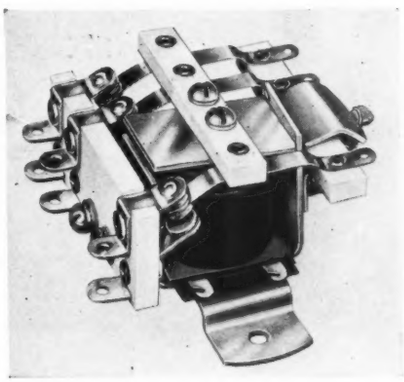
Magnetic Contactors

General-purpose alternating current contactors furnished in sizes 0 and 1 provide a safe and convenient method of remotely controlling electric circuits from one or more push buttons or pilot devices. These Colt contactors, knows as Bulletins 501 and 502, are horse-

power rated for motor control and can be employed where overload protection is not required or is otherwise provided. They are suitable for handling single phase or polyphase a.c. motors, or for use as flexible relaying devices for control systems such as are used in machine tools, switchboards and special control panels. An important feature is the 3-point ball bearing suspension of the movable electro magnet assembly, reducing friction to a minimum and guiding contacts into correct alignment. Other features include double break silver-to-silver contacts; vertical solenoid type contactors with weight of laminated core sufficient to open contacts; and E shaped magnets correctly proportioned to give a strong pull with low power consumption. Colt's Patent Fire Arms Mfg. Co., Electrical Div., Hartford, Conn.

Small Relays

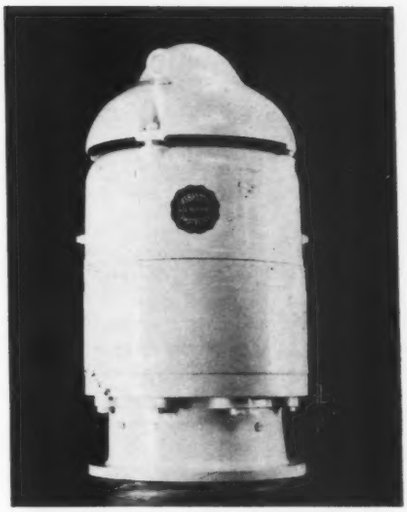
Designed to meet requirements for a small, rugged unit of high-current capacity and low coil wattage operation, this new series of small relays has applications in mobile, marine and aircraft fields, as well as for industrial uses where compactness is a factor. Insulation is Alsimag, Bakelite or high-frequency Bakelite. Contacts are ¼ in.



silver with wide spacing sufficient to handle 15 amp. at 110 volts, a.c. and 7 amp. d.c. at 110 volts. Contacts available in two-pole double-throw, three-pole double-throw, and four-pole double-throw. Coil operation can be had from 6 volts to 250 volts a.c. and from 2 volts to 115 volts d.c. Allied Control Co., Inc., 227 Fulton St., New York, N. Y.

Explosion-Proof Motor

This new vertical explosion-proof motor is suitable for locations in which flammable volatile liquids, highly flammable gases, mixtures or other flammable substances are present, and for locations in which combustible dust is present. The unit is fan-cooled and has asbestos protected windings which are of particular importance since these motors are rated for a 55 deg. C. rise.



Available in a variety of mounting flanges and a mounting bracket is available to fit it to any design of machine without additional adaptors or plates. U. S. Electrical Motors, Inc., 200 E. Slauson Ave., Los Angeles, Calif.

Molding Compound

A new development in high impact phenolic molding compounds, known as Durez 1910, is the third in the new series of 1900 materials which differ radically in particle size from any phenolic compound heretofore available. Durez 1910 contains graphite and was developed especially for such applications as bumper shoes, refrigerator lock bolts and other parts where minimum frictional resistance is desirable. All previous impact materials of this type have been of very fluffy consistency and difficult to handle in feeders and hoppers. Durez 1910 has a particle size comparable to dry rice. Specific gravity is 1.45; bulk factor is 3.6:1. Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y.

Synthetic Enamels

A new line of synthetic enamels that air-dry so hard in 24 hours that they will not "paper print" are known as Coprene enamel, and have a chlorinated rubber base. They air-dry dust-free in a very few minutes, and become hard overnight under normal application conditions. This hardening extends through the entire coating, thus making it resistant to handling and wrapping. Similar hardening can be obtained by force drying for 1 hr. at 200 deg. F. Coprene enamels are supplied in clear, black, white, and colors, and also in silver, copper, and other metallic lusters. They are claimed to have good adhesion,

good resistance to weather and chemicals, and retain their gloss, flexibility and color well. Applicable to all kinds of metal products and wood, either over a surfacer to produce a smooth finish or directly on the grain. Maas & Waldstein Co., 438 Riverside Ave., Newark, N. J.

Blueprint Cabinet

Extreme flexibility of arrangement, to meet the filing requirements of any drafting room, is provided in this line

of improved blueprint filing cabinets. These units, available in three-drawer and five-drawer cabinets in four sizes, are claimed to operate so easily that even fully loaded drawers glide open or closed without binding when using one handle only. Smallest size cabinet is for drawings 24x18 in. Largest is for blueprints measuring 48x36 in. All units are finished in durable olive green baked enamel. All-Steel Equip Co., Aurora, Ill.

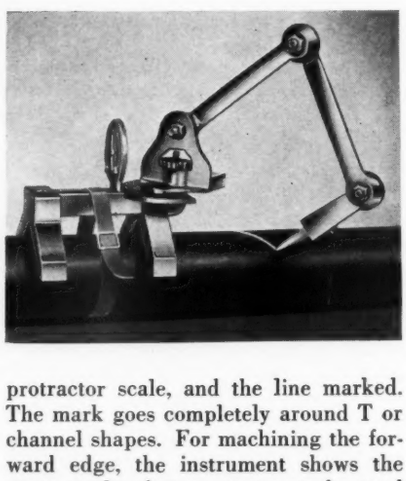
Erasing Machine

In order to overcome frequent changing of the eraser necessitated by short eraser tips previously used the new Bruning hollow shaft erasing machine

has an eraser 7 in. long, fitted into a tubular armature shaft. This long, cylindrical rubber core can be fed out as it wears down and tightened at the lower end of the instrument by a chuck. The motor unit has an impeller-type fan mounted on the shaft within the strong light-weight die-cast aluminum motor housing, insuring cool operation. An SKF precision ball bearing at the chuck end gives long, trouble-free, quiet operation. To turn the machine "on" for either continuous or intermittent operation, a convenient sliding control button lies just underneath index finger. Charles Bruning Co., Inc., 100 Reade St., New York, N. Y.

Layout Protractor

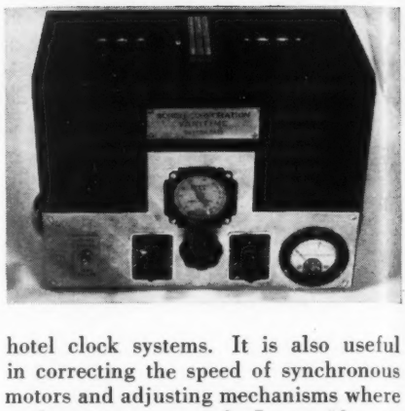
Accurate layouts for any angle of cut or round surfaces are possible with the "Trumark Junior" protractor. Time and material are saved through accurate cuts made without templets or involved calculations. On any rectangular form, the instrument is held squared to the edge or corner, the desired angle is set on the



protractor scale, and the line marked. The mark goes completely around T or channel shapes. For machining the forward edge, the instrument shows the exact angle of any cut, or can be used as a marking edge on small cuts. For marking pipe, the "Trumark" is firmly held in place by a strap. Two levels show exact position for the instrument. The desired angle is set on the 180-deg. scale and the flexible marking arm then scribes a line completely around the pipe. The device is all die-cast, with marking arms held in position by fiber disks. Tru-Line Corp., 6022 Wilshire Blvd., Los Angeles, Calif.

Varitime

This instrument, known as the Soren Varitime, is supplied in several sizes for varying the speed of synchronous electric motors used with controls, timing systems, school, hospital and



hotel clock systems. It is also useful in correcting the speed of synchronous motors and adjusting mechanisms where such motors are used. It provides an adjustable frequency range of from 18 to 240 cycles. It is housed in a sturdy steel cabinet, and the 30 watt model weighs about 20 lb. It is capable of adjusting the speed of synchronous electric motors over a 5 to 1 range. Commonwealth Engineering Co. of Ohio, Dayton, Ohio.

Bearing Bronze

Elements of this new bearing bronze, known as Monarch Metal, are combined in a hermetically sealed crucible which protects them from contact with furnace gases or oxygen while they are melting, and the resultant alloy is water-cooled by means of a secret process. This method prevents hard abrasive tin and lead oxides, results in bearings which will run with less friction, heat and noise than those made of ordinary high-lead bronze, and causes better dispersion and nodulation of lead which makes the alloy more heat resistant. No graphite solution is necessary for breaking in these bearings, because they will not seize or gall their shafts even in the case of lubrication failure. Although the lead content of all Monarch analyses is unusually high, tests show them to be superior in hardening and compression resistance to any other high-lead, tin and copper alloy. Monarch Alloy Co., Ravenna, Ohio.

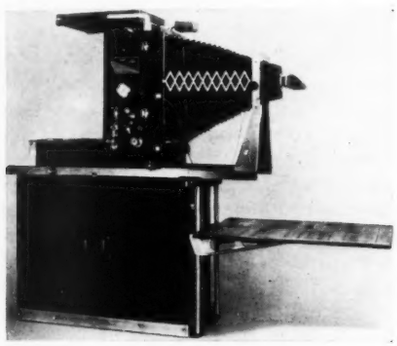
S.A.E. 4640 *Steel*

S.A.E. 4640 Steel is now carried in stock in hot rolled annealed rounds, in sizes from 1 in. to 5 in. Because of its high fatigue resistance, toughness, and ability to attain a high degree of hardness with minimum of distortion in heat treatment, S.A.E. 4640 is one of the best gear steels of the medium carbon grades. It will develop high hardness and tensile strength with a relatively mild quench. It also shows higher impact resistance at high hardness than other 0.40 carbon alloy steels in the

same or slightly lower price range. The machinability of both annealed and heat-treated S.A.E. 4640 is superior to other steels of this type. It can be satisfactorily machine-finished at 400 Brinell. In addition to gear applications, this steel is recommended for arbors, racks, worms, boring bars, spindles, clutches, piston rods, bolts, studs, ratchets, pins, and other applications where high shock resistance and toughness are necessary at relatively high hardnesses. Joseph T. Ryerson & Son, Inc., 16th & Rockwell Sts., Chicago, Ill.

Copying Machine

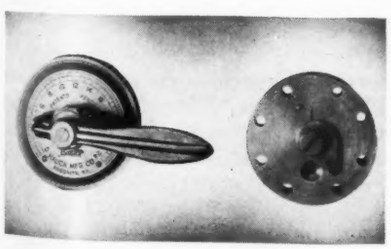
The improved "Rectigraph" photocopying machine, designed to copy exactly by photography anything written,



printed or drawn in actual reduced or enlarged sizes, comprises a complete machine which photographs, develops and fixes the print in the unit itself. This machine is said to employ exclusive features to facilitate rapid and economical copying for all types of work. Haloid Co., Rochester, N. Y.

Oil Valve

This improved valve has a straight-line flow characteristic with the flow directly proportional to the area of the slot opening and the number on the calibrated dial. It is designed specifically to regulate the oil flow on any type of oil burner and can be used wherever quick, accurate manual or automatic regulation of oil flow is desired. The flow of oil is governed by a cam with a knife edge rotating over the slot orifice. Cam works with very little bearing pressure, and is ground to produce a straight-line discharge curve. Houck Mfg. Co., 124–136 Tenth St., Brooklyn, N. Y.



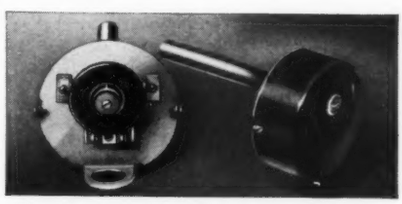
Drafting Tables

Two new drafting tables, known as Metapost and Primo Metapost, are built of attractive satin chrome tubular steel and baked black morocco castings. The

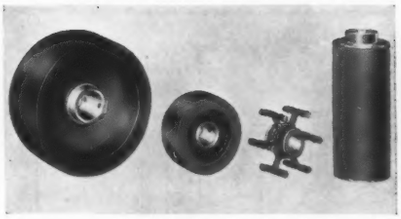
Primo Metapost table is quickly adjusted by turning a hand wheel that will raise the working surface from 35½ in. to 43 in. The top of the table can be tilted from front to back at an angle of 60 deg. by manual adjustment of two clamps. The Metapost has the same adjustment features with the exception of the hand wheel. The table tops, available in eleven sizes ranging from 31x42 in. to 48x96 in., are made of selected soft texture pine 1⅛ in. thick. Frederick Post Co., P. O. Box 803, Chicago, Ill.

Thermoswitches

These new thermoswitches consist of a Fenwal cartridge thermal switch to which has been applied a junction box, thereby providing facility for attaching BX cable or conduit to a terminal block within a protective cover. The air thermoswitch (illustrated) cartridge extends into ducts and provides tem-



perature control with adjustment change within a range from —50 deg. to 400 deg. F. Contact rating is 10 amp., 115 volts a.c. Immersion thermoswitch, with immersion cartridge, has similar ratings. Fenwal, Inc., Ashland, Mass.



Fiber Rolls

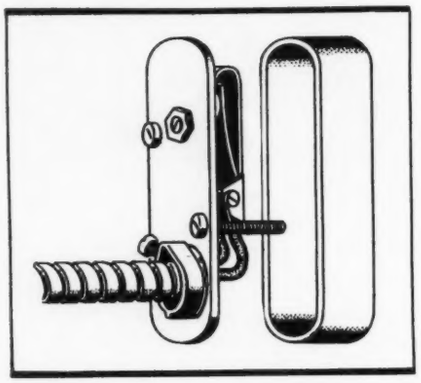
This new construction for highly compressed fiber small and medium-sized rolls or pulleys consists of a tough rugged hub and spider of zinc alloy cast under high pressure into the body of the fiber. Two distinct advantages are claimed: improved machine performance and low cost for rolls. Principal uses are in applications where slippage of rubber, fabric or leather belts or tapes are undesirable in rolls or pulleys. Rockwood Mfg. Co., 1801 English Ave., Indianapolis, Ind.

Bearing Material

Carobronze, a new bronze bearing material, is said to have ability to carry high loads and speeds; remarkable ability to resist shock loads; freedom from any consequential wear, even under the most exacting conditions; low frictional resistance; high ductility at temper of greatest length and hardness; resistance to deformation under heavy loading; resistance to corrosion and erosion. The alloy contains 91.2 per cent copper, 8.5 per cent tin, and 0.3 per cent phosphorous. Carobronze can be obtained in three grades, each with a separate set of physical properties suitable for the application for which it is intended. It is manufactured in tubular form, about ½ in. to 3½ in. outside diameter, within reasonable limits of wall thickness. Rods can be supplied in all sizes from wires up to bars of about 3½ in. dia. The material is supplied in longer lengths, so that it can be machined easily and economically on automatic screw machines. Revere Copper & Brass, Inc., 230 Park Ave., New York, N. Y.

Strip Thermostat

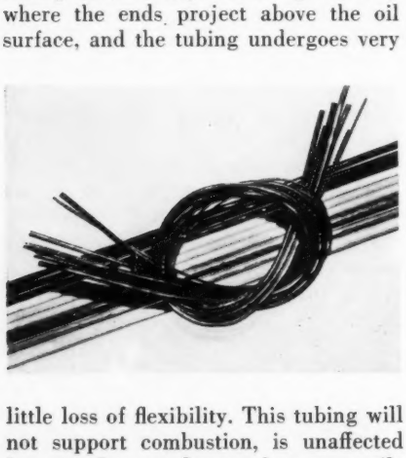
Suitable for heavy duty loads of 1,500 watts at 115–230 volts a.c., this thermostat is especially suitable for controlling temperatures of electrically heated surfaces such as hot water heaters, hot plates and heated machine parts. The thermostatic element is mounted on a removable cover which gives greater accessibility and facilitates easy wiring. When mounted, all live metal parts are



concealed in the assembly. Available in maximum temperature ranges of 300 deg., 450 deg., and 700 deg. F. Supplied with normally closed contacts to open with rise in temperature and with normally open contacts to close with rise in temperature. George Ulanet Co., 89 Kinney St., Newark, N. J.

Insulating Tubing

A new electrical insulating tubing made of high heat-resisting extruded plastic. Known as Irv-O-Lite XTE-100 tubing, it shows little if any loss in flexibility after heating to 185 deg. F. for 60 days. It will not lose its form up to 240 deg. F., which is the softening point. Heated for 125 hours at 185 deg. F. it shows a linear contraction of only 1 per cent. The tubing is flexible down to a temperature as low as 32 deg. F. Immersed in transformer oil at 220 deg. F. for 48 hours, the tubing shows a slight swelling but only where the ends project above the oil surface, and the tubing undergoes very



little loss of flexibility. This tubing will not support combustion, is unaffected by petroleum solvents, has a tensile strength of 2,000 lb. per sq. in., has high resistance to tear and abrasion, and has a dielectric strength, dry, of 750 volts per mil. Manufactured in all standard sizes from No. 20 to ½ in. inside diameter with A.S.T.M. tolerances. Irvington Varnish & Insulator Co., 24 Argyle Ter., Irvington, N. J.

Induction Motors

Open-type sleeve-bearing squirrel-cage induction motors designed especially for general purpose drive applications such as machine tools, pumps, auxiliary drives, are more attractive and compact than ever before, and are stronger mechanically. Rigid cast frame maintains air-gap between stator and rotor, assuring high efficiency operation. Frame improvements include new sealed sleeve bearing having a combination vestibule and felt washer seal, and a larger oil reservoir capacity. New wire insulation gives maximum dielectric strength, toughness and flexibility. Combination slot cells, with reinforced cuffs, protect windings from

abrasion, and coil ends are taped for reinforcement against strains of full voltage starting. All motors are dynamically balanced, and windings are given a high-voltage radio frequency test. These new type CS motors are available in ratings from ½ to 5 hp., at speeds from 875 to 3,600 r.p.m., for operation on 110, 220, 440 and 550 volts, two and three phase a.c. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Porcelain Enamel

A new white porcelain enamel cover coat for refrigerators, ranges, washing machines and similar equipment. By means of a further development, this new enamel known at Neopake now fuses at the same temperature as antimony-bearing porcelain enamel. The burning temperature of the antimony-free porcelain enamels formerly was 1,500 to 1,550 deg. F., the Neopake now fuses at 1,480 deg. to 1,500 deg. F. This results in lower fuel cost, less warped ware, faster production, and a more uniform and lower cost finish per unit. The demand for antimony, created by National Defense needs, impelled the intensive research program that led to this development. The Porcelain Enamel & Mfg. Co., Eastern & Pemco Aves., Baltimore, Md.

500-Watt Rheostat

Type F-500 rheostat has exceptionally smooth, close control, each turn of wire being a separate resistance step. Resistance wire or ribbon is wound over a solid porcelain core, each turn being locked against shifting by vitreous enamel. Metal-graphite contact brush rides on large flat surface and has spiral connector integrally molded, thus eliminating all wiping contacts except between brush and resistance element. Ample air space between winding form and cast aluminum base cools rheostat with minimum heat transfer to mounting surface. Available in standard values from 1.0 to 2,500 ohms, Hardwick-Hindle, Inc., Newark, N. J.

Flat Spray Nozzles

Spray pattern of this new nozzle is flat with slightly heavy center at higher pressures, and can be had in a number of different spray angles. Nozzles are available in ⅛ to ½ in. male pipe con-

nection. Capacities range from 0.5 to 10 gal. per min. at 10 lb. per sq. in. and 1 to 20 gal. per min. at 40 lb. per sq. in. Standard stock construction is brass or iron; other materials can be specified. Spraying Systems Co., 4011-21 W. Lake St., Chicago, Ill.

Manufacturers' Publications

Materials

MAYARI R—Bethlehem Steel Co., Bethlehem, Pa. Catalog 156, 32 pages, 8½ x 11 in. Sets forth features, corrosion resistance data, and high-strength properties of Mayari R corrosion resisting steel. Includes many illustrations of typical applications.

MOLDING PLASTICS—Bakelite Corp., 30 E. 42nd St., New York, N. Y. Bulletin, 32 pages, 8½ x 11 in. Gives general discussion of bakelite phenolic molding plastics, tables of properties and excellent illustrations of applications of all Bakelite molding materials.

PLEXIGLAS—Rohm & Haas Co., Inc., Washington Sq., Philadelphia, Pa. Bulletin, 4 pages, 5x8 in. Directions for handling, fabricating, polishing, and cleaning transparent Plexiglas.

POLYVINYL ACETATE—R. & H. Chemicals Dept., E. I. du Pont de Nemours & Co., Wilmington, Del. Bulletin A-1349, 4 pages, 8½x11 in. Gives summary of general properties, specifications, and applications of polyvinyl acetate emulsions, solids and solutions.

PUMP PARTS OF NICKEL—International Nickel Co., 67 Wall St., New York, N. Y. Bulletin 10-40, 16 pages, 8½x11 in. "Practical Pumping Problems and How They Are Solved" discusses in detail the uses of Monel, "K" Monel and "S" Monel.

STEEL SHAPES—Commercial Shearing & Stamping Co., 1775 Logan Ave., Youngstown, Ohio. "Commercial Standard Steel Shapes," Section 2, 10 pages, 8½ x 11 in. Illustrates and gives dimension data for 12 steel shapes that can be purchased as standard without die or tool charges.

Mechanical Parts

BALL BEARINGS—Stephens-Adamson Mfg. Co., Aurora, Ill. Catalog 840, 32 pages, 8½ x 11 in. Describes various types of Sealmaster ball bearings, gives load capacities and bearing life ratings, includes much engineering data, and gives standard dimensions.

CONVEYOR BELTS—B. F. Goodrich Co., Akron, Ohio. Booklet, 12 pages, 8½ x 11 in. Describes principle of cord construction of the Goodrich cord conveyor belt, and sets forth advantages of cover adhesion, flexibility, mildew resistance, freedom from stretch, vulcanized and metal splices.

DISTRIBUTION PANELBOARD—The Trumbull Electric Mfg. Co., Plainville, Conn. Circular 325, 4 pages, 8½ x 10 in. Fully describes the new Type MH Multi-Breaker distribution panelboard for automatic circuit breaker protection.

LEATHER PRODUCTS — Alexander Bros., 406 N. 3rd St., Philadelphia, Pa. Catalog A-116, 34 pages, 8½ x 11 in. Contains many engineering tables and much engineering data, belt hints and application photos covering the complete line of Alexander Bros. products.

RUBBER PRODUCTS—Hewitt Rubber Corp., Buffalo, N. Y., Catalog, 36 pages, 8½ x 11 in. Illustrates and describes all types of industrial hose, couplings, packing, and gives engineering tabular data.

SCREW PRODUCTS—Central Screw Co., 3501 Shields Ave., Chicago, Ill. Catalog K, 115 pages, 6¼ x 9½ in. Illustrates and gives standard dimensions for complete line of screws, bolts, nuts and rivets. The leatherette-bound book is thumb tabbed for ready reference.

SPEED CONTROL—Reeves Pulley Co., Columbus, Ind. Form G-410, 8 pages, 8½ x 11 in. Illustrates and describes the three Reeves speed control units and gives many pages of typical installations with production details.

VALVES—B. F. Goodrich Co., Akron, Ohio. Catalog Section 9787, 2 pages, 8½ x 11 in. Sets forth features of Goodrich Vulcalock valves, rubber lined and suitable for corrosive and abrasive fluids.

VALVES—John S. Barnes Corp., 301 So. Water St., Rockford, Ill. Bulletin data sheet, 4 pages, 8½ x 11 in. Describes Barnes Power & Control Panel and the Barnes Index Power & Control Panel for use in hydraulic lines.

VALVES—Kennedy Valve Mfg. Co., 1161 E. Water St., Elmira, N. Y. Catalog 63, 240 pages, green clothboard covers, 8 x 10¾ in. This well-illustrated and complete catalog covers all types of bronze and iron body valves and valve accessories.

Electrical Parts

D.C. MOTOR MAINTENANCE — General Electric Co., Schenectady, N. Y. Bulletin GEA-3488, 8 pages, 8 x 10½ in. Contains general information on motor maintenance and inspection, and includes a trouble correction chart for d.c. motors.

DISTRIBUTION DUCT — Bulldog Electric Products Co., 7610 Jos. Campau Ave., Detroit, Mich. Bulletin 403, 44 pages, 8½ x 10 in. Gives complete information on flexible light and power circuits for industrial plants and commercial buildings with Bull-Dog Distribution Duct.

LIQUID LEVEL CONTROL—Fred H. Schaub Engineering Co., 325 W. Huron St., Chicago, Ill. Catalog 640-M, 12 pages, 8½ x 11 in., sets forth complete details of Schaub Magnetrol liquid level controls. Illustrations and hook-up diagrams cover typical applications.

OHM'S LAW CALCULATOR—Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill. Slide rule type calculator gives a quick answer to any Ohm's Law problem and has a convenient stock resistor unit selector. Send 10 cents to cover handling cost.

WIRING CALCULATOR—Bulldog Electric Products Co., 7610 Jos. Campau Ave., Detroit, Mich. Slide rule type calculator, based on the 1940 National Electrical Code, gives quick data on wire sizes, capacities and conduits and data for wiring motor circuits. It shows most of the generally used information in complete and simple form.

Fabrication Methods

BRAZING ALLOYS—Handy & Harman, 82 Fulton St., New York, N. Y. "The Minute Men of Metal Joining," 4 pages, 8½ x 11 in. Describes the two low temperature brazing alloys, Sil-Fos and Easy-Flo.

STAINLESS CLAD STEEL—Ingersoll Steel & Disc Div., 310 So. Michigan Ave., Chicago, Ill. "Manual of Welding and Fabricating Procedures," 16 pages, 8½ x 11 in. Improvement in welding and fabricating techniques to assure maximum strength, corrosion resistance and ductility are included in this recently revised booklet. Sketches, diagrams and the text describe all welding and fabricating procedures.

Finishes

PYROFLEX—The Porcelain Enamel & Mfg. Co., Eastern and Pemco Aves., Baltimore, Md. Folder, 4 pages, 8½ x 11 in. Brief description of Pyroflex, the new low-cost inorganic porcelain enamel.

Miscellaneous

PYROMETERS—The Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa. Catalog 15-E, 24 pages, 8 x 10½ in. Illustrates, describes constructional features and operating advantages of indicating, recording and control millivoltmeter pyrometers. Catalog 1104, 36 pages, 8 x 10½ in. Sets forth features of Brown potentiometer pyrometers, and includes much useful engineering data.

THERMOMETERS AND PYROMETERS—C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y. Catalog 1101F, 32 pages, 8½ x 11 in. Covers electric thermometers and pyrometers, photo-electrically balanced recorders, indicators, controllers and recording controllers. Potentiometers for thermocouples and slide-wire wheatstone bridges are also covered.

Books and Bulletins

Sales Engineering

BERNARD LESTER—*200 pages, 5¾x 8¾ in. Blue clothboard covers. Published by John Wiley & Son, Inc., 440 Fourth Ave., New York, N.Y. Price $2.*

Many of the principles of sales engineering, although seemingly remote from those of design engineering, should be kept in mind by all design engineers who are interested in the sales appeal of their products. Although Mr. Lester's purpose in writing this book is to place before the sales engineer, without sales-promotional adornment, the principles of sales engineering, he has not confined his book to sales engineers, but has kept in mind the usefulness of his subjects to highly technical engineers who desire a better knowledge of sales principles and practice.

After briefly defining sales engineering and emphasizing the importance of knowing the market and the motives which actuate buying, the author discusses the principles and procedures. The last few chapters in the book get down to the details of selling a technical product. In order to clarify his points, the author uses many short case histories.

Vibration of Road and Rail Vehicles

B. S. CAIN—*258 pages, 6 x 8¾ in. Numerous charts and diagrams. Blue clothboard covers. Published by Pitman Publishing Corp., 2 West 45 St., New York, N. Y. Price $5.*

Originally conceived by the Committee on Industrial Aerodynamics of the American Society of Mechanical Engineers, this book makes available to the engineer the results of extensive investigations by automobile companies, the Electric Railway Presidents Conference Committee, the Transit Research Corporation and railroad companies. Whenever possible, simple general principles are given with a minimum of mathematics. However, for complicated subjects it has been necessary to include advanced mathematics.

The book gives a well-written analysis of vibration theory and then proceeds to static and dynamic factors, in spring suspension and engine mounting for automobiles, utilizing theoretical and test results as a basis for the discussion. This same procedure is followed for street car and railroad vibrations, the latter being comprehensively analyzed.

Mechanical Vibrations

J. P. DEN HARTOG—*Second Edition, 448 pages, 6x9 in. Blue clothboard covers. Published by the McGraw-Hill Book Co., Inc., 330 West 42nd St., New York, N.Y. Price $5.*

This second edition includes discussions of the more important advances made in the study of mechanical vibration during recent years. The new material is concerned chiefly with electrical measuring instruments, centrifugal pendulum dampers, aircraft and ship propellers, and automatic balancing machines. Many new problems have also been included. A four-page appendix has been added listing formulas that are used frequently in practice.

The subject matter covers kinematics of vibration, vibration systems with various degrees of freedom, multicylinder engines, rotating machinery, self-excited vibrations, and systems with variable or non-linear characteristics. The volume is arranged for use both as a textbook and for the practicing engineer who is desirous of obtaining a working knowledge of mechanical vibrations.

Kinematics of Machines

GEORGE L. GUILLET—*Fourth Edition, 200 pages, 5½x8½ in. Blue clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $3.*

The fourth edition of this textbook contains some changes so that the material is in better agreement with present practice. Many new problems have been added. The chaper on gears has been revised to conform with recent standards.

In general the contents deal with displacement, velocity, acceleration, theory of instant centers, velocity and acceleration in plane motion, slider-crank and cam mechanisms, rolling contact, toothed gearing and gear trains, flexible connectors, and miscellaneous mechanisms. The book concludes with a collection of forty drafting room problems.

Practical Design of Small Motors and Transformers

E. MOLLOY, EDITOR—*176 pages, 103 illustrations, 5½x8 in. Green clothboard covers. Published by Chemical Publishing Co., 148 Lafayette St., New York, N.Y. Price $2.*

Mr. Molloy in this book leaves little to the imagination of the design engineer who is faced with the task of designing, constructing or rebuilding small motors and transformers. After a brief and easily understood but nevertheless complete discussion of the mathematics involved in the design, the subjects are treated with a step-by-step explanation of practical methods of construction and rewinding. Each step is illustrated with an action photograph. Two chapters cover the rewinding of motors, and chapters cover the making of a $\frac{1}{18}$ hp. universal motor and a typical design of a ⅛ hp. squirrel cage motor.

• • •

Photo Relays
Their Theory and Application

F. H. SHEPARD, JR.—*28 pages, 6x9 in., published by Allied Control Co. Inc., 227 Fulton St., New York, N. Y. Price 25 cents.*

The five chapters of this booklet give an excellent general treatise on the photoelectric cell, its principles of operation, necessary equipment and applications. Although the book is written in an easy-to-read style, numerous charts and wiring diagrams provide technical information essential to the design engineer.

Viscosity Index Tables

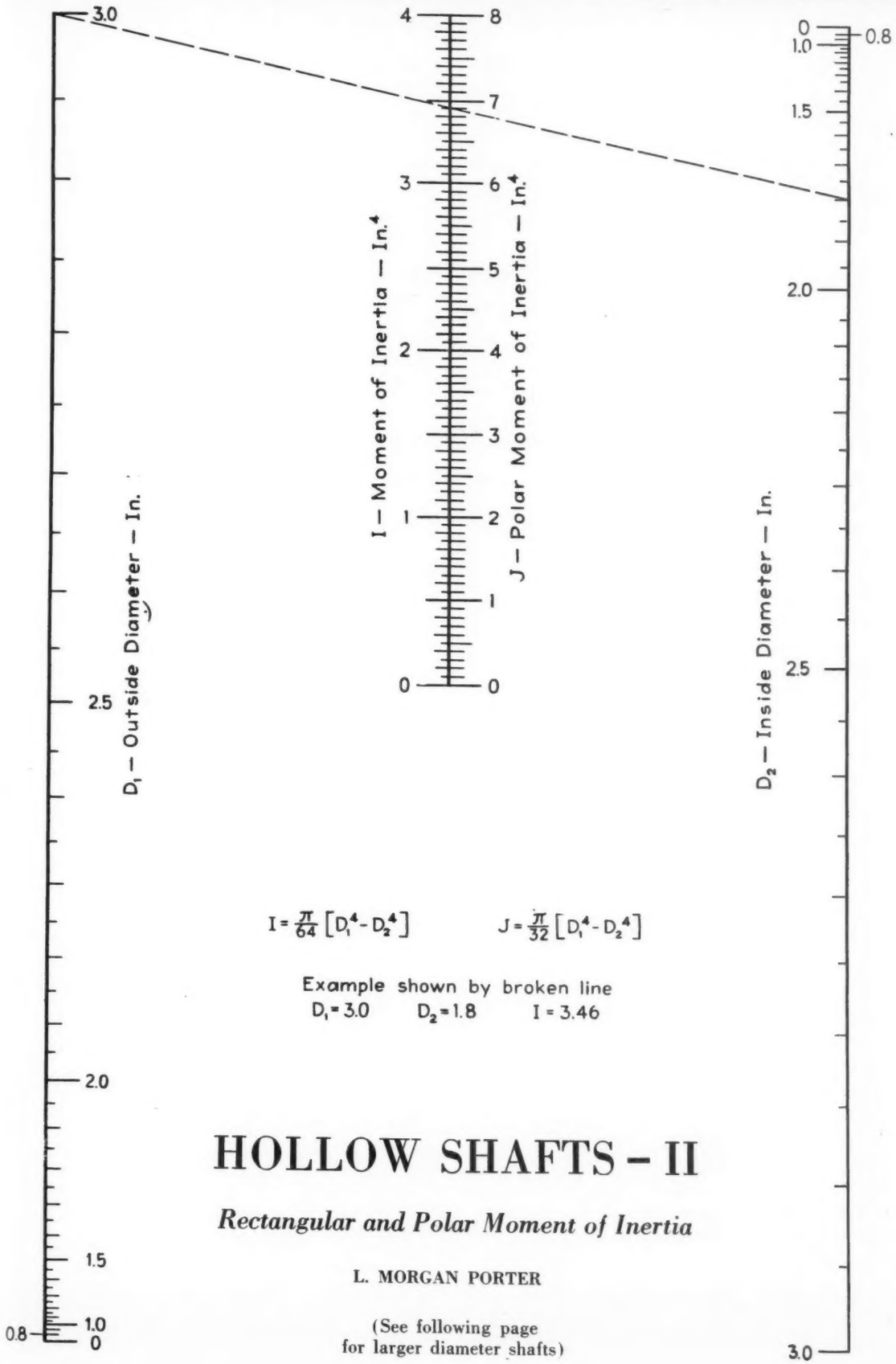
36 pages, 6x9 in. Published by American Society for Testing Materials, 260 Broad St., Philadelphia, Pa. Single copy price 50 cents.

These tables provide convenient references to the viscosity indexes of petroleum oils and lubricants. The index calculated from basic Saybolt Universal Viscosity is tabulated against Saybolt at 100 sec. under values at 210 deg. F. for 40 to 161 sec.

Aluminum Casting Alloys

90 pages, 5½x8½ in. Published by Aluminum Company of America, Pittsburgh, Pa.

Written expressly for engineers, this well illustrated and well written pocket-size booklet tells how to select aluminum casting alloys, explains general foundry principles and includes a 12-page section on the design of aluminum castings. Design sketches and tabulated data on mechanical and physical properties supplement the text which covers the general considerations. A special chapter lists and describes the common Alcoa aluminum casting alloys available in ingot form.



$$I = \frac{\pi}{64}\left[D_1^4 - D_2^4\right] \qquad J = \frac{\pi}{32}\left[D_1^4 - D_2^4\right]$$

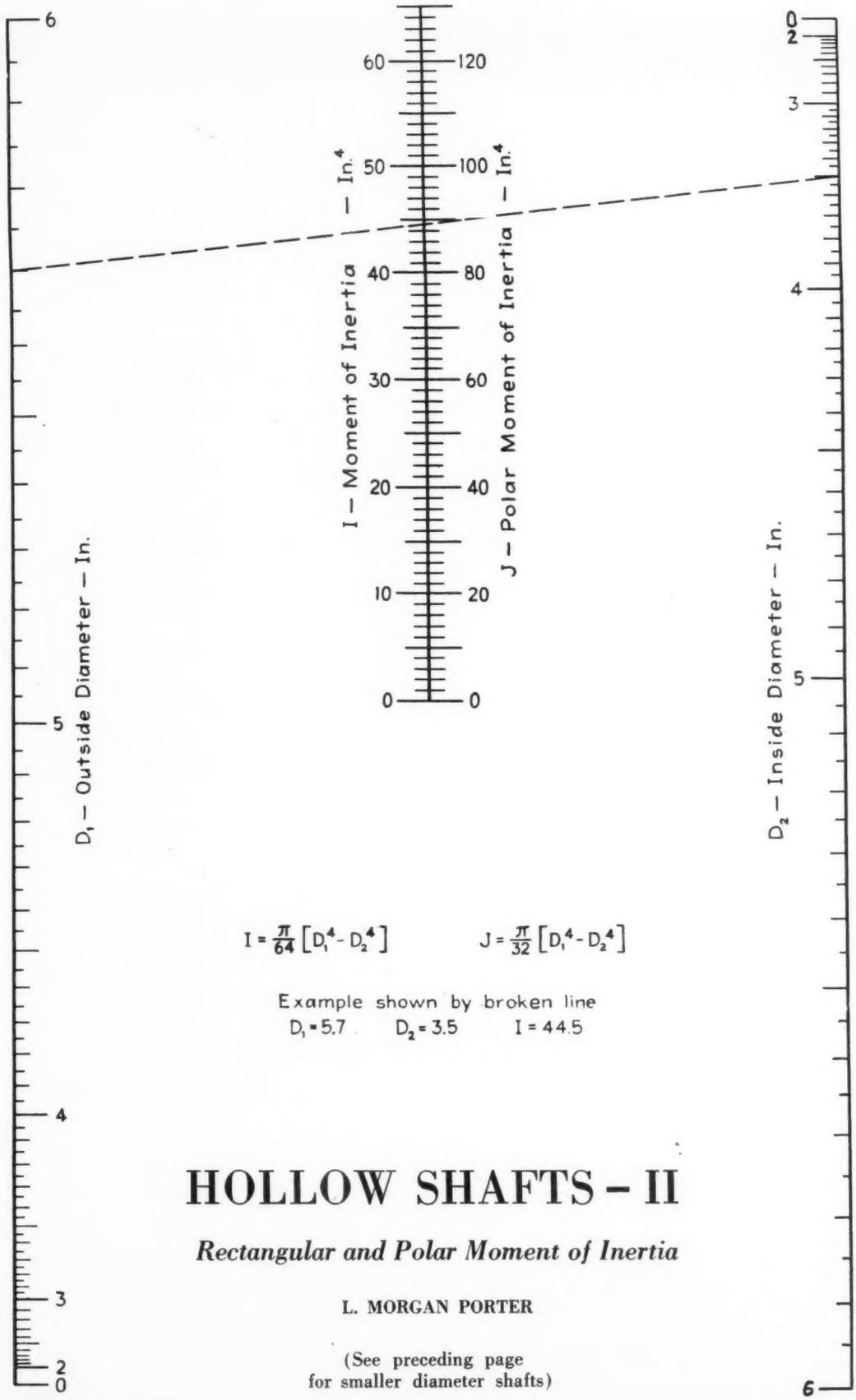
Example shown by broken line
$D_1 = 3.0$ $D_2 = 1.8$ $I = 3.46$

HOLLOW SHAFTS – II

Rectangular and Polar Moment of Inertia

L. MORGAN PORTER

(See following page for larger diameter shafts)



$$I = \frac{\pi}{64}\left[D_1^4 - D_2^4\right] \qquad J = \frac{\pi}{32}\left[D_1^4 - D_2^4\right]$$

Example shown by broken line
$D_1 = 5.7$ $D_2 = 3.5$ $I = 44.5$

HOLLOW SHAFTS – II

Rectangular and Polar Moment of Inertia

L. MORGAN PORTER

(See preceding page
for smaller diameter shafts)

PRODUCT ENGINEERING ✦ REFERENCE BOOK SHEET